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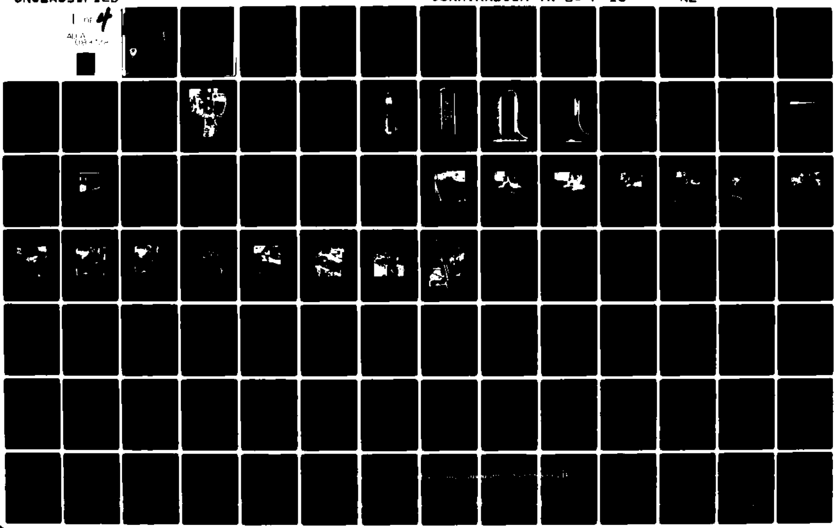

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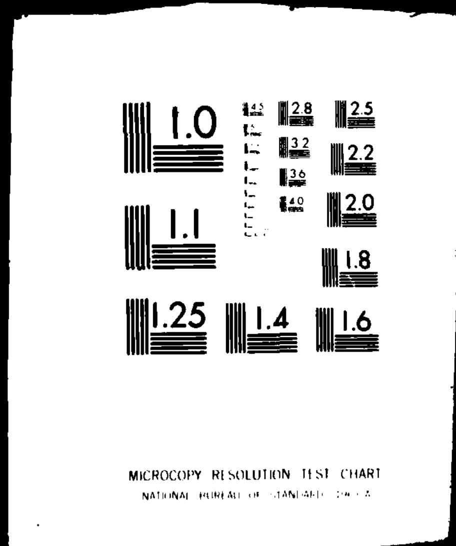

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LEVEL IV

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USA AVRADCOM
Report No. TR-80-F-16

MANUFACTURING METHODS AND TECHNOLOGY
(MANTECH) PROGRAM

CONVEYORIZED RADIO FREQUENCY CURE OF EPOXY GLASS COMPOSITES.

Lawrence C. Ritter
Boeing Vertol Co.,
P.O. Box 16858,
Philadelphia, PA 19142

May 1980

338

FINAL REPORT, 19 Jan 79 - 19 Feb 80

Contract No. DAAG46-79-C-0009

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Prepared by
ARMY MATERIALS AND MECHANICS RESEARCH CENTER

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this work is to develop a dielectric heating capability for curing fiber reinforced composite structure. The specific objectives were to develop optimum radio frequency (rf) cure cycles for resin/fiber composites, establish process parameters relative to feed rate, rf power levels, electrode spacing, and material thickness variations.

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Present manufacturing technology for curing epoxy/fiber composite structure involves the use of large energy consuming facilities (ovens, autoclaves, resistant or radiant heaters, etc.) which entail costly flow times. The use of direct dielectric heating can provide, in some instances, a cost effective alternate curing method. It has been shown that a cost savings of 75 percent can be realized by the use of radio frequency curing over conventional curing by conduction heating.

In the basic principles applied to cure by dielectric heating, an alternating electric field causes oscillatory displacements in the charged components of the dielectric, the energy for motion being absorbed from the electric field. The energy absorbed by the molecules is translated into rotational kinetic energy of the entire molecule, resulting in a temperature increase.

FOREWORD

This project was accomplished as part of the U.S. Army Aviation Research and Development Command Manufacturing Technology program. The primary objective of this program is to develop, on a timely basis, manufacturing processes, techniques and equipment for use in production of Army materiel. Comments are solicited on the potential utilization of the information contained herein as applied to present and/or future production programs. Such comments should be sent to: U.S. Army Aviation Research and Development Command, Att.: DRDAV-EGX 4300 Goodfellow Boulevard, St. Louis, Missouri 63102.

This technical report describes the development work concerning the radio frequency (rf) cure of epoxy/fiberglass composites. The program is being conducted with Government-furnished equipment in cooperation with the U.S. Army Materials and Mechanics Research Center (AMMRC), Watertown, Massachusetts. The report covers the development work conducted under AMMRC Contract DAAG-46-79-C-0009 for the period 19 January 1979 to 19 February 1980. The following Boeing Vertol Company personnel have contributed actively to the program during the contract.

Project Engineer	Lawrence C. Ritter
Technician	Walter Lashno
Development Mechanic	William Lentz

The contributions of Mr. Walter Lashno and Mr. William Lentz to this project are acknowledged, Mr. Lashno for his assistance in preparing the laminates, assembling the tooling and operating the rf equipment, and Mr. Lentz for cutting the prepreg, making the layups and separating the cured laminates.

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1. INTRODUCTION

Present manufacturing technology for curing epoxy/fiber composite structure involves the use of large energy consuming facilities (ovens, autoclaves, resistant or radiant heaters, etc.) which entail costly flow times. The use of direct dielectric heating can provide, in some instances, a cost effective alternate curing method. A recent study[1] has shown that a cost savings of 75 percent can be realized by the use of radio frequency curing over conventional curing by conduction heating.

In the basic principles applied to cure by dielectric heating, an alternating electric field causes oscillatory displacements in the charged components of the dielectric, the energy for motion being absorbed from the electric field.[2] The energy absorbed by the molecules is translated into rotational kinetic energy of the entire molecule, resulting in a temperature increase.

The material absorbs energy at the rate given by:

$$\text{Power (P)} = KfE^2 \frac{A}{t} \epsilon' \tan\delta \times 10^{-12}$$

Where

K = Constant (based on units)

f = Frequency in megahertz

E = Field strength in volts

A = Area of material in square inches

t = Thickness of material in inches

ϵ = Dielectric constant of material

δ = Loss tangent

This equation shows that the heating effect is directly proportional to the frequency, directly proportional to the square of the applied voltage and directly proportional to the dielectric constant and the loss tangent.[3]

The capacity of a substance to absorb high frequency energy is described by the term loss tangent; the higher the loss tangent, the more energy absorbed and the greater the heating effect; the lower the loss tangent the less energy absorbed and the less the heating effect.

In most applications, the dielectric constant and the loss tangent are fairly constant over the dielectric heating frequency range, at a fixed temperature. Therefore, a best frequency need not be sought; the desired heating rate is obtained by selecting a frequency range and voltage for which it is practical to build equipment and for which a suitable electrode system can be designed.

Dielectric heating acts below the surface of a dielectric material and heats all parts of the volume simultaneously with substantially greater speed and uniformity than conventional methods. Some advantages related to dielectric equipment are:

1. The energy can be turned on and off instantaneously.
2. It is efficient in that it does not throw off wasted heat.
3. It can be precisely and accurately controlled.
4. It can heat selected sections of a part, leaving other sections cool.
5. It is easy to operate, basically long lived and requires little maintenance.

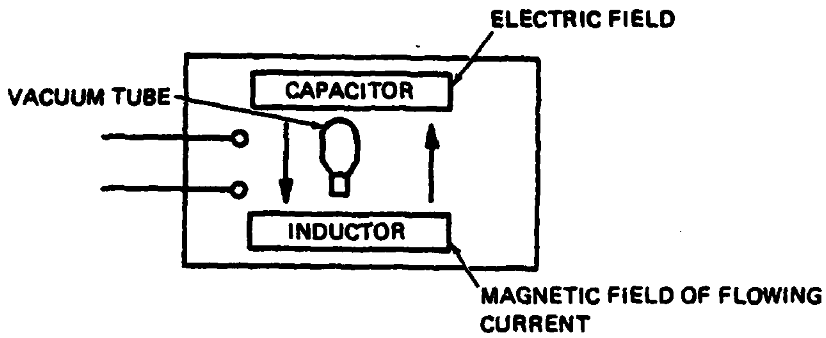
The basic theory of electronic heating is to change standard AC line voltage to radio frequency. The high-frequency voltages are actually generated in a capacitor-inductor combination. Energy is stored alternately in the capacitor and in the inductor. In the capacitor, energy is stored in an electric field; and in the inductor energy is stored in the magnetic field of the current flowing in the inductor. Current flowing in the inductor charges the capacitor to one polarity; when it is fully charged the current stops flowing and then begins flowing in the opposite direction through the inductor to charge the capacitor fully in the opposite direction. The vacuum tube acts as a switch between the power supply and the inductor-capacitor combination, switching current from the power supply at the appropriate times required by the capacitor-inductor. The high-frequency voltage, up to tens of thousands of volts, is delivered through a transmission line to the work applicator fixture. Figure 1 illustrates a high frequency generator.

For dielectric heating, two ranges of radio-frequencies are used. For most processes, a frequency somewhere in the 1-200 millions of cycles per second (megahertz) range, usually called high-frequency or radio frequency heating is used. For a small but increasing amount of work, frequencies above 890 megahertz (MHz) called microwave heating are in use. The fundamental relationship for electromagnetic waves,

$$\text{Frequency } (MH_z) \times 10^6 \times \text{wavelength (m)} = 3 \times 10^8 \text{ (vel of light)}$$

indicates decreasing wavelength with increasing frequency. The wavelength of 30 megahertz is 10 meters, commonly used for high frequency heating. The wavelength for 1000 megahertz is 0.1 meter which is considered short for a radio wave, and is, therefore, called a microwave. Equipment cost for microwave equipment exceeds that of the lower frequency (80 to 100 megahertz) equipment by a factor of 4 and operating costs are reported to be some 50 percent higher. Also, a greater health hazard exists with microwave equipment due to the possibility of radiation leakage. Manufacturers must comply with Federal regulations covering radiation leakage to meet safety requirements.

In high-frequency heating, the material to be heated is usually placed between two electrodes. When high frequency energy is applied to the electrodes, the material between the electrodes is heated uniformly throughout its volume. In microwave heating the energy is applied by horns or waveguides, and its effect decreases to a negligibly low value at some point below the surface, the depth of the penetration depending on the frequency and on the material being heated. Due to the nature of the microwave, auxiliary devices (propellers, waveguides) are required to disperse the energy and guard against localized heating in the load or "hot spots".



1. Energy is stored alternately in the capacitor and in the inductor.

2. The vacuum tube acts as a switch between the power supply and this inductor-capacitor combination.

3. The high voltage is delivered through a transmission line to the work applicator fixture.

Figure 1. The High Frequency Generator

High-frequency generators are available in a wide range of output power ratings, from about 50 watts up to many hundreds of kilowatts. Equipment delivering 2 or 3 kilowatts can be obtained up to 200 or 300 megahertz; 25 kilowatts at 100 megahertz and 100 kilowatts at 30-40 megahertz. Microwave generators can be had at 900 to 2500 megahertz with outputs up to 25 kilowatts.

An important consideration in the 1 to 100 megahertz heating is that the field is concentrated between the electrodes and virtually all of the heating takes place in this area. This is an important difference from microwave heating in which ultra high frequency electrical energy, at frequencies typically 25 times as high as this 100 megahertz energy, is generated in a power tube, conducted through concentric lines or waveguides to a cavity in which the energy must be contained to be effective in heating.

The dielectric curing process proposed by Boeing Vertol Company pertains to passing a self-contained, pressurized tool containing the uncured epoxy/fiberglass part, between flat-plate electrodes and through the emitted radiofrequency field by means of a conveyor belt as illustrated in Figure 2. The approach is also compatible with the cure of a part of complex geometry, varying thickness and the use of inexpensive nonmetallic tooling.

Based on the Boeing Vertol Company preliminary investigations into rf curing in 1973-1974 and an unsolicited proposed to the U.S. Army Aviation Research and Development Command (AVRADCOM)[4] the Army contracted for the design and manufacture of a conveyorized radio frequency oven.

The conveyorized radio frequency 20-kilowatt (90-100 megahertz) dielectric heater was dedesigned and manufactured by the LaRose Associates, Cohoes, New York, under Contract DAAG46-76-0064 for the U.S. Army Aviation Research and Development Command (AVRADCOM), St. Louis, Missouri, under the cognizance of the Army Materials and Mechanics Research Center, Watertown, Massachusetts. This unit was delivered to Boeing Vertol in August 1977 and installed in Plant 3, Building 3-07.

Specifications for the equipment, identified as Model 20/CV/90, are given in Table 1.

LaRose Associates provided Boeing Vertol personnel the necessary equipment checkout and operational instruction under the cognizance of personnel from the Army Mechanics and Materials Research Center. The checkout test results are presented as Appendix A. The conveyorized radio frequency oven is shown in Figure 3.

Communication personnel from the U.S. Army Communications Electronics Engineering Installation Agency, Fort Huachuca, Arizona, monitored the frequency of the rf equipment (September-October 1977), both from inside Building 3-07 and at a distance of 2,000 to 3,000 feet outside the building for possible interference with overhead aircraft navigational and communication equipment and with commercial television and radio. Measurements taken with the equipment in both the load and no-load conditions indicated there was no discernible interference through the 10th harmonic. The results of the survey are given in Appendix B.

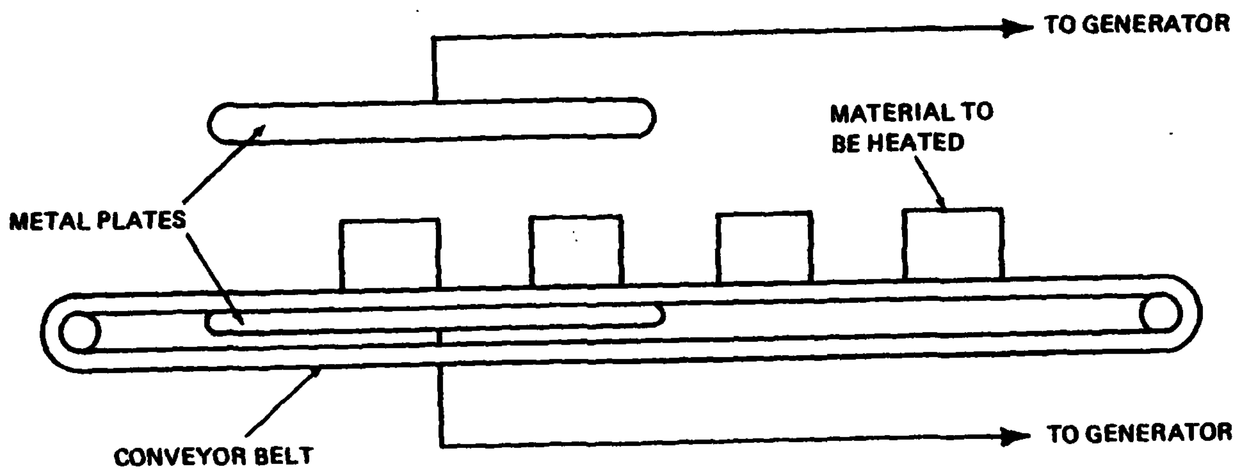


Figure 2. Dielectric Heating System with Conveyor

Subsequent IR&D work in 1978,[5] by Boeing Vertol led to a contract from the Army Mechanics and Materials Research Center, Watertown, Massachusetts to establish rf parameters for curing epoxy/fiberglass and to measure the mechanical properties of cured laminates.

TABLE 1. MODEL 20/CV/90 SPECIFICATIONS

Power Output	20 Kilowatts
Electrode Area	22 x 35 Inches
Electrode Spacing	4 to 16 Inches
Frequency Range	72 – 108 Megahertz
Power Line Voltage Required	230 or 460 ± 60 Cycle, 3 Phase
Power Line Current Required	
230 volt operation	100 Ampere, 3 Phase (minimum)
460 volt operation	60 Ampere, 3 Phase (minimum)
Line Voltage Fuses in machine	
Plate Transformer Fusing	
230 Volts	100 Amperes
460 Volts	60 Amperes
Control Transformer Fusing	
230 Volts	30 Amperes
460 Volts	15 Amperes
Power Tube	(1) THERMALL 6-1
Rectifiers	(6) THERMALL SR152 (modules)
Safety	Panel Interlock Switches Overvoltage Breakdown Protection D.C. Overload Protection Grounded Case and Frame
Plate Current	4 Amperes maximum
Grid Current	See note
Belt Speed	0.5 to 5 feet/minute

NOTE: For ideal operation at 3.6 amperes of plate current the grid current should be 575 milliamperes. Grid current meter is marked in red below 550 and above 800 milliamperes. The white area of the dial from 550 to 800 milliamperes is the ideal operating range for the grid current.

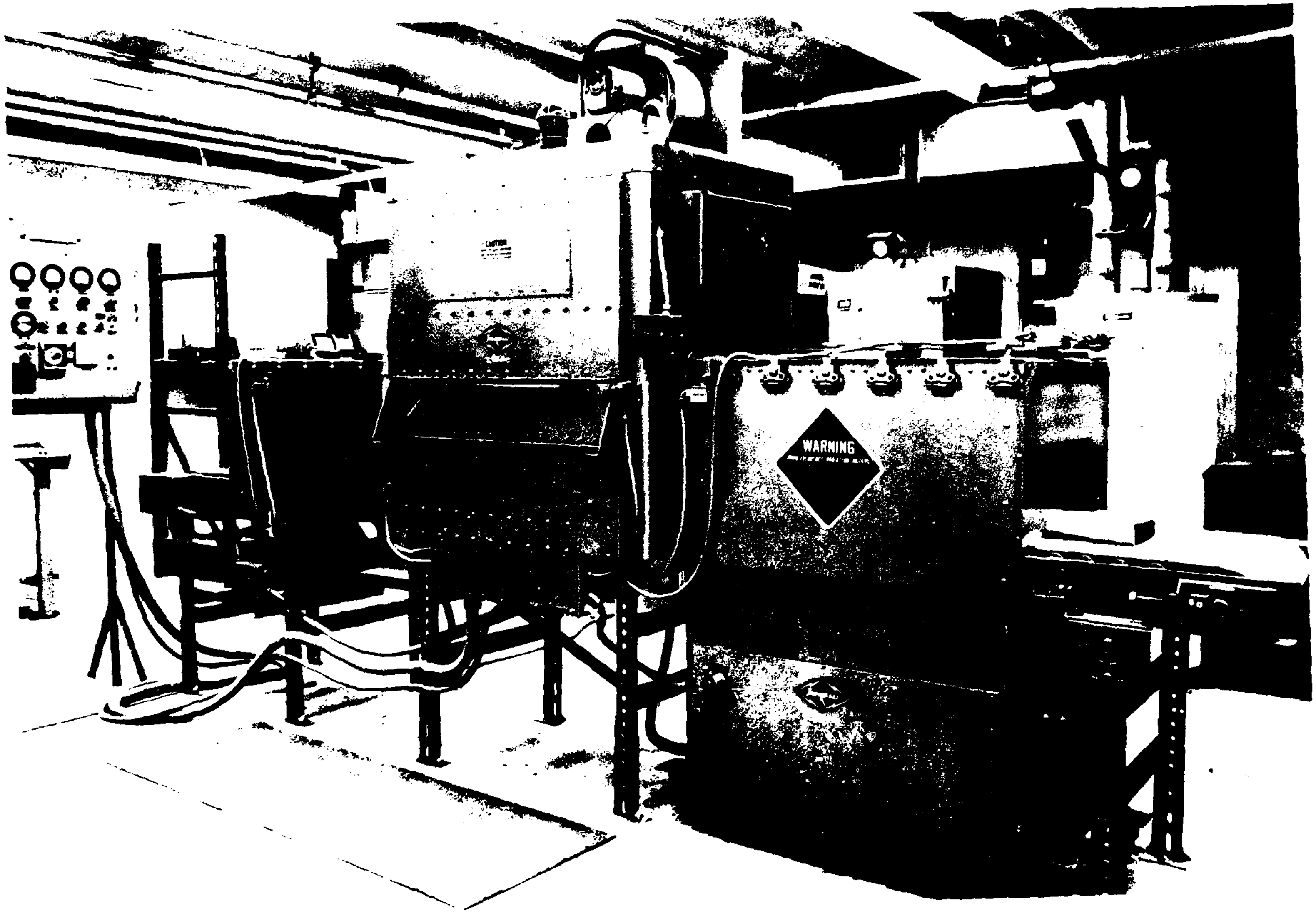


Figure 3. 20-Kilowatt, 90-100 Megahertz Conveyorized Radio Frequency Oven

2. CONTRACT NUMBER

DAAG-46-79-C-0009

3. PROJECT TITLE

CONVEYORIZED RADIO FREQUENCY CURE
OF EPOXY/GLASS COMPOSITES

4. DISCUSSION

4.1 OBJECTIVES

The purpose of this work was to develop a dielectric heating capability for curing fiber reinforced composite structure. The specific objectives were to develop optimum radio frequency (rf) cure cycles for resin/fiber composites, establish process parameters relative to feed rate, rf power levels, electrode spacing, and material thickness variations.

4.2 MATERIAL

The material used in this program was Scotchply Type SP-250-E-33-W-456, Lot 7, Jumbo 50, Unidirectional, supplied in 72 yard rolls, 6-1/2 inches wide, and manufactured by the Minnesota Mining and Manufacturing (3M) Company, St. Paul, Minnesota. The 3M Company Product Manufacturing Code for this particular batch is W456, Lot 7, Jumbo 50. A copy of the 3M Affidavit and Quality Control Data are presented as Appendix C.

The Boeing Vertol material inspection data are presented as Appendix D.

4.2.1 Laminate Qualification Properties

A press cured laminate of the Scotchply material was prepared by Boeing Vertol personnel, for qualification purposes, in accordance with requirements of Section 5.2 of BMS 8-196A. The laminate properties were measured and are noted below in Table 2.

TABLE 2. PROPERTIES OF PRESS CURED LAMINATES

Property	BMS-8-196A Requirement	Results
Void Content, Max. % by Volume	3.5	1.53
Fiber Content, Avg. % by Volume	Report	63.5
Composite Density Avg lb/in.^{3}	Report	0.074
Ply Thickness, Mils	8.5 ± 1.0	7.0
Tension (KSI)/Modulus (MSI)	140/5.5	167.9/7.4
Flexure (KSI)/Modulus (MSI)	160/5.3	223.5/7.9

The laminate met all requirements with the exception of per ply thickness which measured 1/2 mil less than the minimum required.

4.3 TOOLING

Several nonmetallic tooling materials are suitable for use in a rf field. These materials are "transparent" to rf and have appropriate electrical, mechanical and thermal properties. The materials considered for this work were ceramic, fiberglass/epoxy, polysulfone, poly-4-methyl-pentene-1, silicone rubber and polypropylene. Silicone rubber and polypropylene proved to be the most practical and most economical. Silicone rubber was used to make the inflatable pressure bag. The decision to use polypropylene for the matched die tool was based on low dissipation factor (0.0003) and a 2.2 dielectric constant. It is readily available, can be machined easily and is relatively inexpensive.

Although the upper temperature capability of 270 to 300^{o}F was of some concern, it was considered that the nonheating characteristics of polypropylene by rf and its poor heat conductivity would allow tooling to sustain epoxy cure cycles without difficulty. Also of concern were the creep and deflection properties of polypropylene with respect to the compacting pressure used during the cure.

To answer this question, several test bars measuring 1 by 1 by 12 inches were prepared and threaded on either end. These were tested in tension to evaluate the strength of the material. Both square and tapered threads were evaluated; it was found that a tapered 8 threads-per-inch provided more than adequate holding power. The material failed in tension at 4,550 psig. The tensile strength of polypropylene is given as 4,900 psig. Figure 4 shows the test specimen.

An empirical determination of the deflection of a 1 by 1 by 12-inch bar of polypropylene was made under a static load of 80 pounds at room temperature. Over an 8-hour period the bar deflected approximately 0.070 inches under this load. Once the load was removed, the bar returned to its original horizontal plane overnight. Since these conditions were more severe than those expected in practice, the findings were acceptable with respect to the use of the material for tooling.

The tooling is in the form of matched mold dies machined from polypropylene plate. It consists of three sections: the bottom containing the laminate to be cured, the midsection floating pressure plate and the top section containing the pressure bag. Six 3/4-inch diameter sighting ports, on six-inch centers, line one side of the bottom section, Figure 5. Figures 6 and 7 show the tooling assembled, top and edge views. This tooling (Figure 8) was designed and machined under the previous Boeing Vertol in-house IR&D effort.

4.4 LAMINATE FABRICATION AND CONFIGURATION FOR RF CURING

The Scotchply epoxy/fiberglass prepreg was fabricated into two laminate configuration: a wedge shape and a constant thickness section. Each laminate was made of 10 sections. To separate each section, a release material was positioned as noted in Table 3.

The wedge shaped laminate was stepped off one inch for each ply. This configuration is illustrated in Figure 9. The wedge was fabricated in two halves which were then faced together. The assembled wedge is shown in Figure 10. A cured constant thickness section is shown in Figure 11.

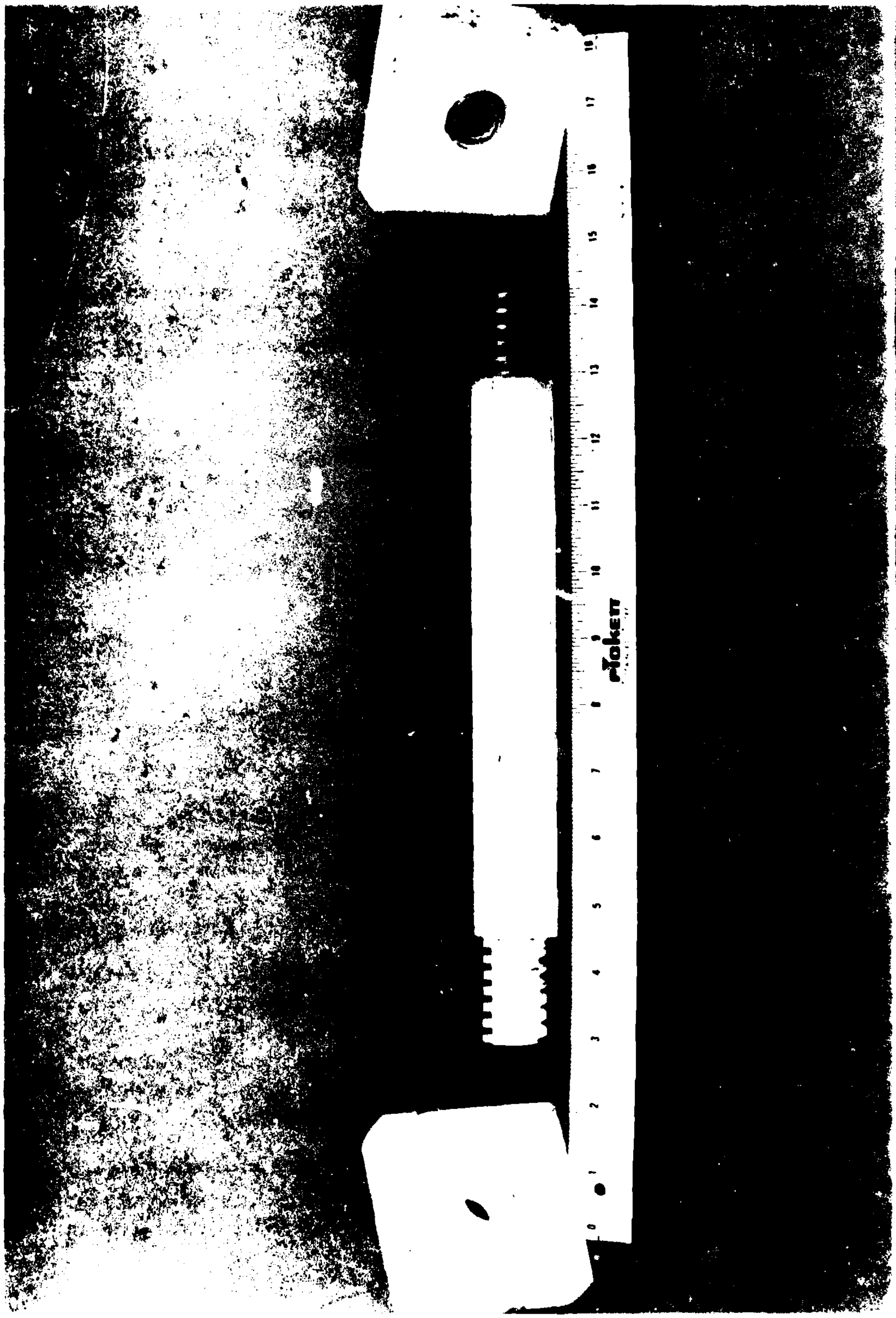


Figure 4. Polypropylene Test Specimen

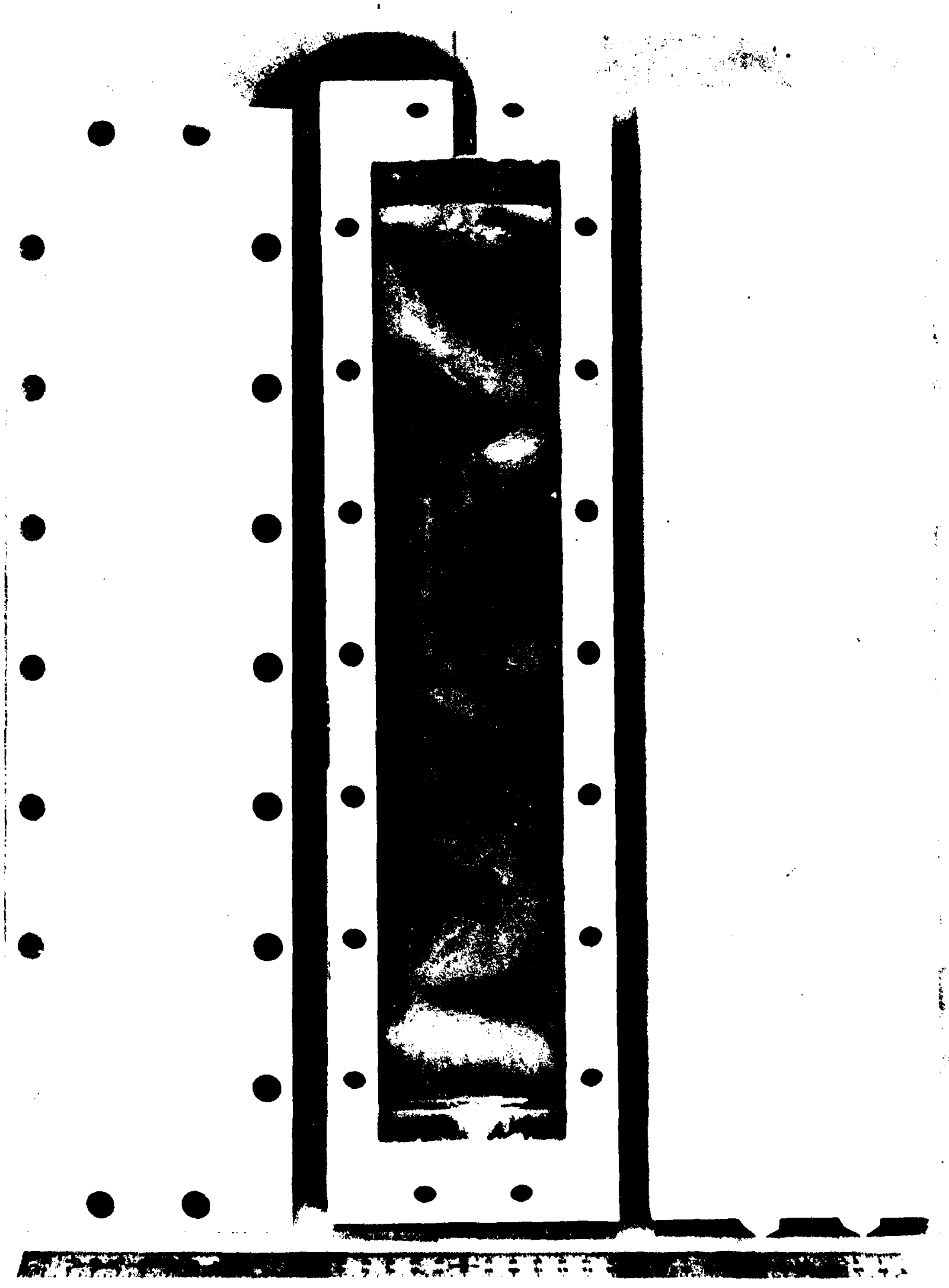


Figure 5. Components of Polypropylene Tooling

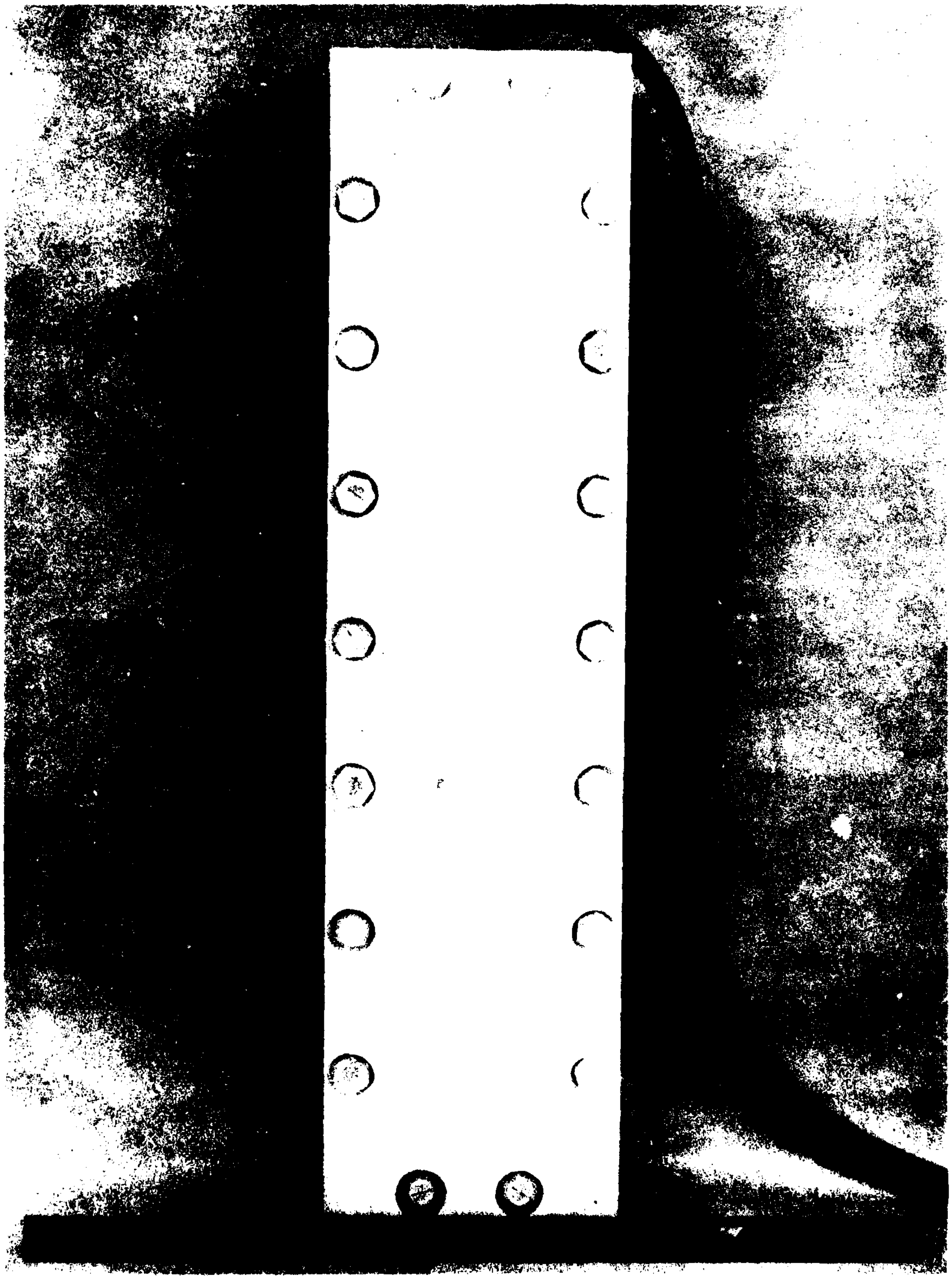


Figure 6. Top View of Assembled Polypropylene Tooling

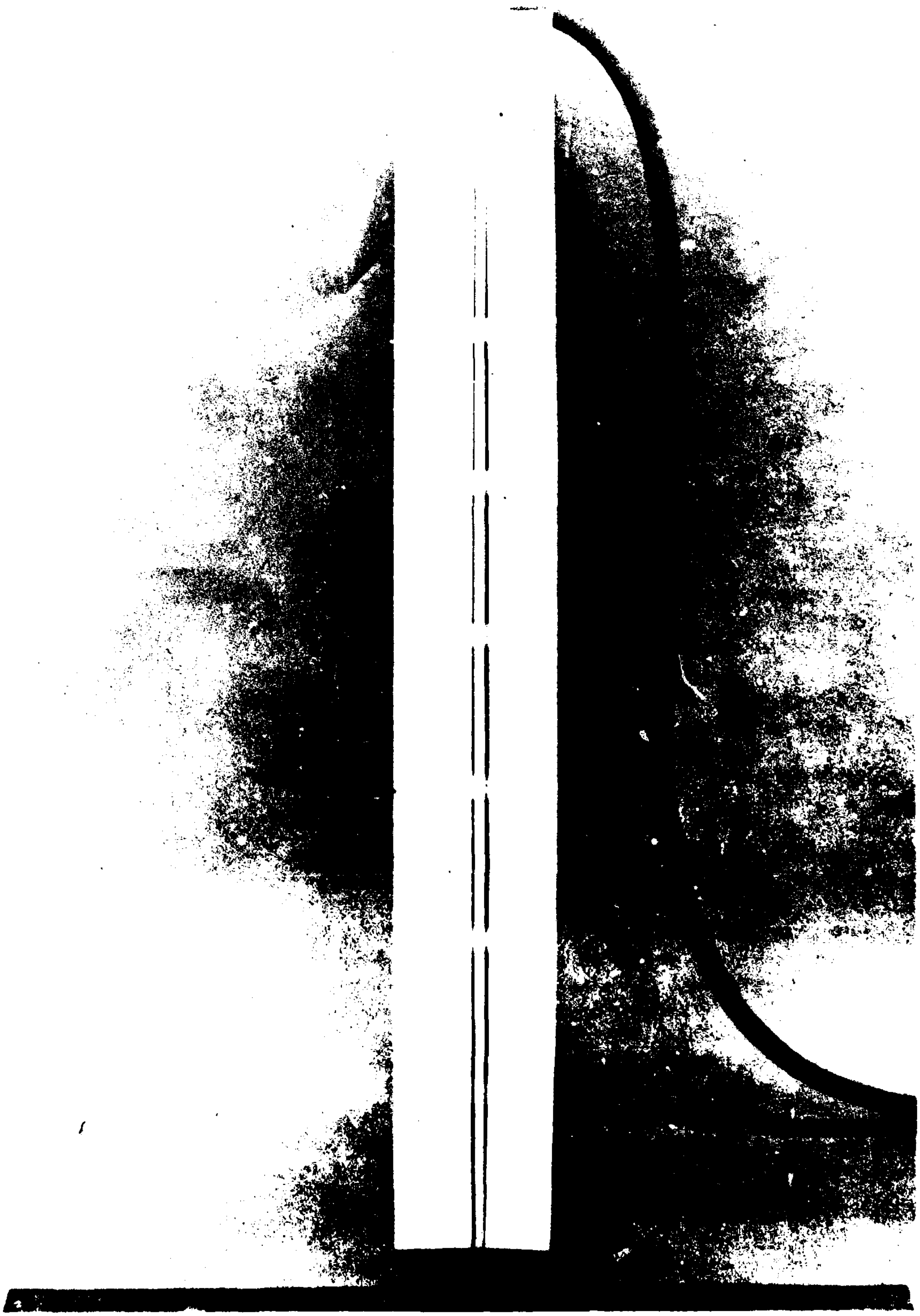


Figure 7. Edge View of Assembled Polypropylene Tooling

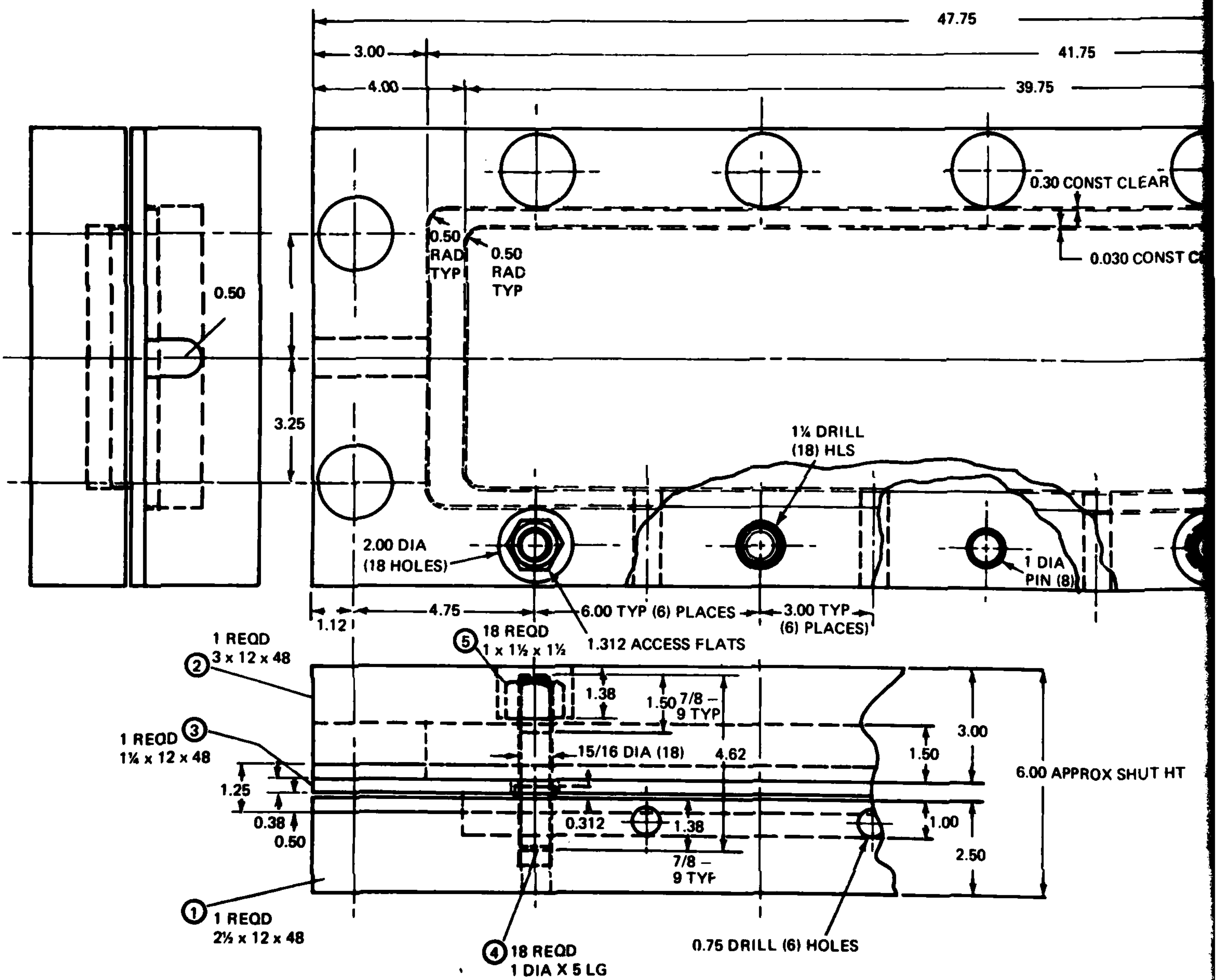
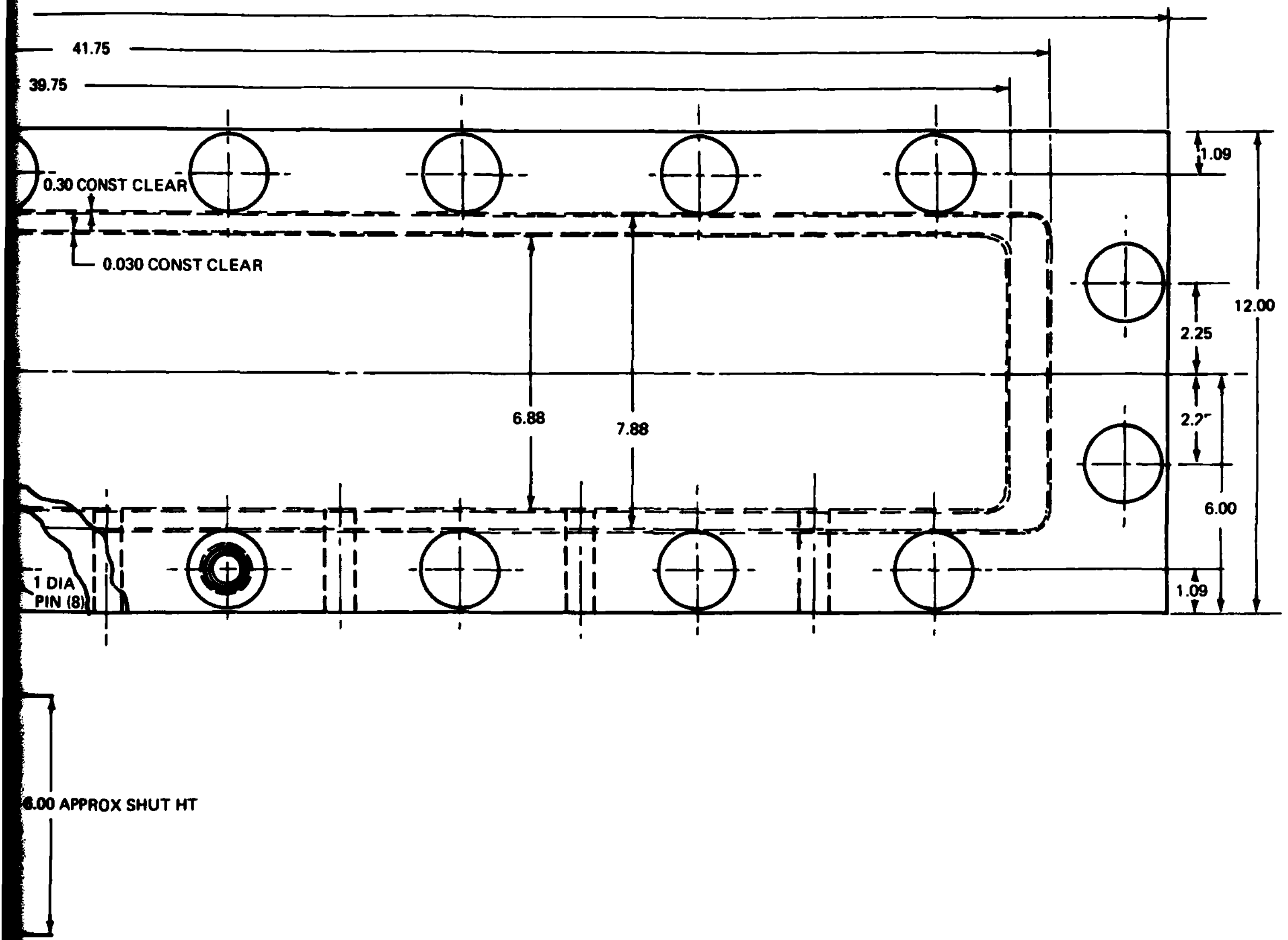


Figure 8. Three Element Polypropylene Mold for RF Curing



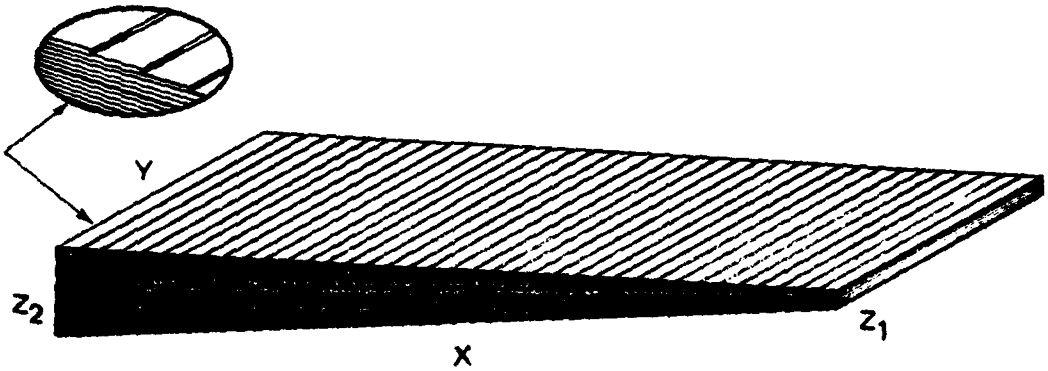
41.75
39.75
1.09
0.30 CONST CLEAR
0.030 CONST CLEAR
12.00
2.25
6.88
7.88
2.2
6.00
1 DIA
PIN (8)
1.09
6.00 APPROX SHUT HT

2

TABLE 3. LAMINATE CONSTRUCTION SPECIFICATIONS

Ply No.	Length (Inches)	Ply No.	Length (Inches)	Ply No.	Length (Inches)	Ply No.	Length (Inches)
1	39	14	36	26	24	38	12
2	39	15	35	27	23	39	11
3	39	16	34	28	22	40	10
4	39	17	33	29	21	41	9
5	39	18*	32	30*	20	42	8
6	39	19	31	31	19	43	7
7	39	20	30	32	18	44	6
8	39	21	29	33	17	45	5
9	39	22	28	34	16	46	4
10	39	23	27	35	15	47	3
11	39	24	26	36*	14	48	2
12*	38	25	25	37	13	49	1
13	37					50*	39
51	39	64	36	76	24	88	12
52	39	65	35	77	23	89	11
53	39	66	34	78	22	90	10
54	39	67	33	79	21	91	9
55	39	68*	32	80*	20	92	8
56	39	69	31	81	19	93	7
57	39	70	30	82	18	94	6
58	39	71	29	83	17	95	5
59	39	72	28	84	16	96	4
60	39	73	27	85	15	97	3
61	39	74	26	86*	14	98	2
62*	38	75	25	87	13	99	1
63	37					100*	39

*Insert Peel Ply After This Ply



1 IN. DROPOFF

X	=	39 IN.
Y	=	6.0 IN.
Z_1	=	0.22 IN.
Z_2	=	1.0 IN.

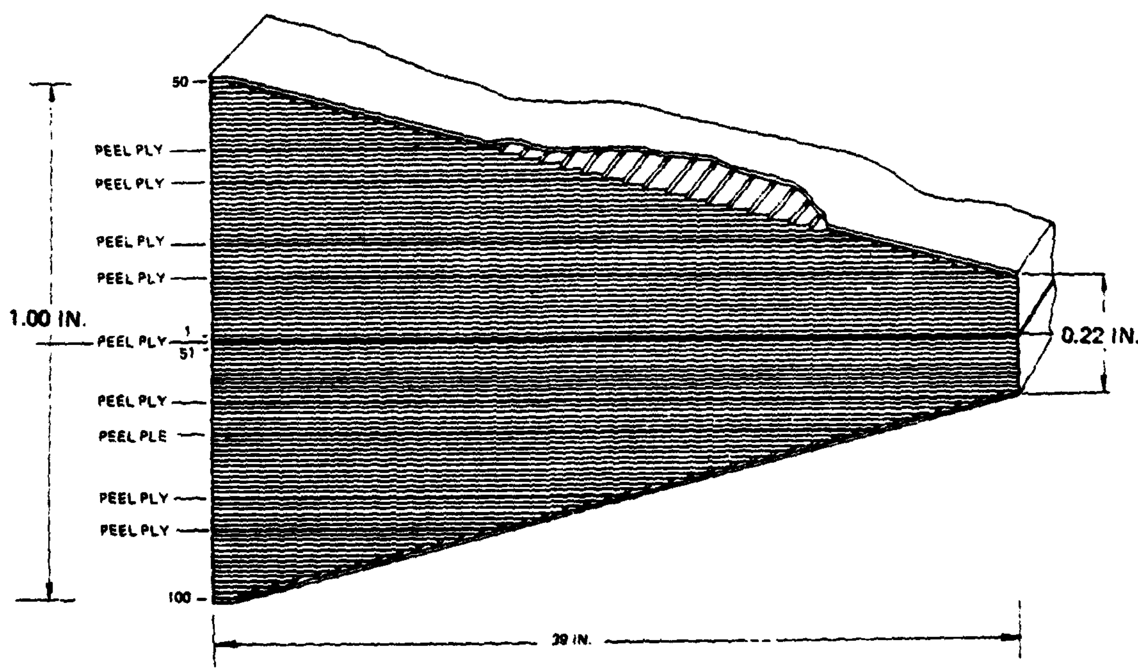


Figure 9. Epoxy/Fiberglass Laminated Wedge Section

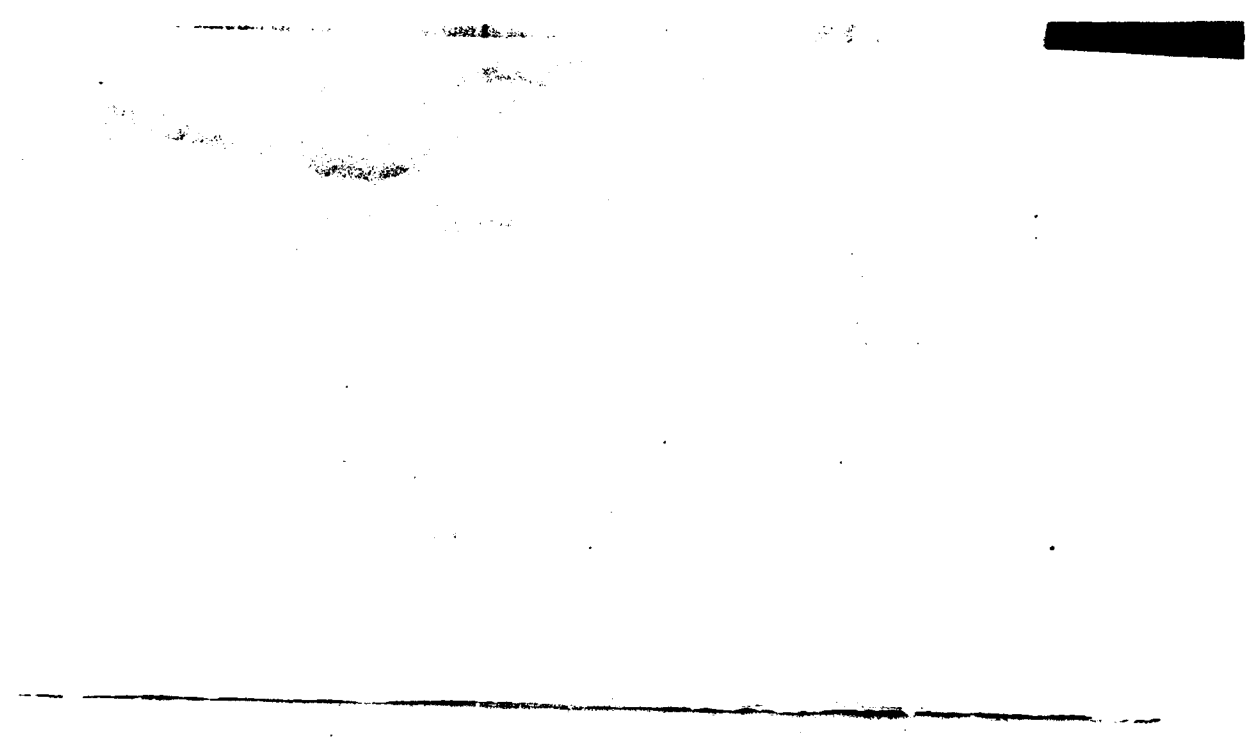


Figure 10. Assembled 100 Ply Wedge (Uncured)

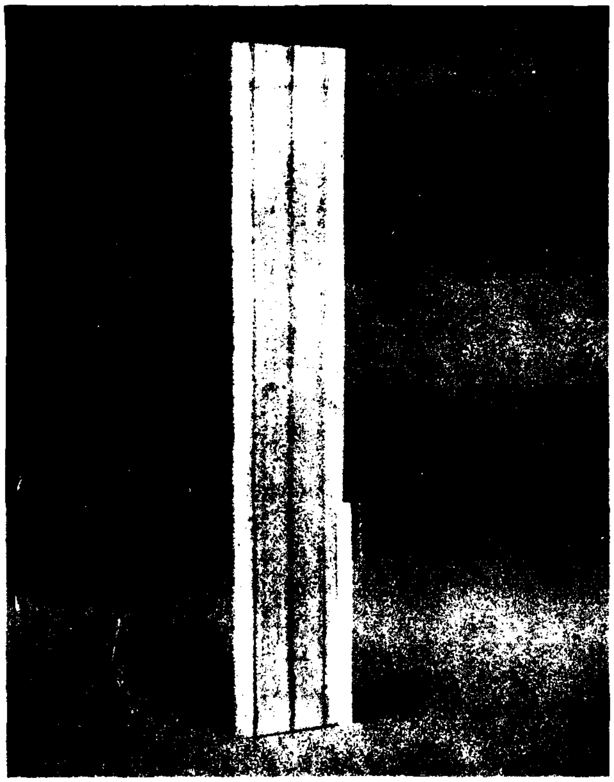


Figure 11. Cured and Trimmed Constant Thickness Section

Exploded views, Figures 12 and 13, of the wedge and the constant thickness section for laminates with unidirectional fibers identify the location and indicate the ply thickness of the different panels. The thick panels are twelve-ply with the exception of panels 5 and 1A which are fourteen-ply, and the thin panels are six-ply. Illustrations for those laminates having $\pm 45^{o}$ or $0^{o}/90^{o}$ fiber orientation are given as Figures 14 and 15. These identify the location of the panels and indicate the respective ply thickness. The total ply count for these laminates is 104.

4.5 LAMINATE AND TOOL ASSEMBLY

After the ten separate layups making up a specific laminated unit had been completed they were arranged in the stacking sequence previously illustrated. Figure 16 shows the last unit ready to be located and Figure 17 the applications of that section to the laminate. The laminate has been placed on a piece of nylon bagging material. When the last section is located, a double thickness of fiberglass bleeder cloth is laid on top, Figure 18. A similar bleeder had been placed on the bottom of the laminate prior to stacking the individual sections. The entire laminate is then encased in the nylon bag which is tack sealed with teflon tape, Figure 19. The purpose of this bag is to contain the resin squeeze out and preclude time consuming post cure tool clean up. A second bag of Teflon film is also used to seal the seam of the nylon bag, Figure 20.

The bagged unit is then placed in the tool cavity, Figure 21, and silicone rubber spacers located, Figures 22 and 23, to facilitate removal of the cured laminate. Next, a polypropylene spacer is inserted, Figure 24. This is a piece of uniform thickness for the constant thickness laminate and a wedge shaped spacer for the wedge section. The floating pressure plate is next located, Figure 25, followed by the top section containing the inflatable silicone pressure bag, Figure 26. The polypropylene nuts are threaded on the studs and the pressure plate snugged down, Figure 27. An initial pressure of 10 psig is applied to the laminate. This was so for all cases except for the first run (No. 14) where an initial pressure of 5 psig was used.

The resin containment bag around the laminate is pierced at each of the temperature sighting holes for controlled flow of squeeze out resin. Figure 28. The squeeze out is collected in a separate throw away trough (not shown) that is attached to the side tool after it is positioned on the conveyor belt. Figure 29 shows the assembled tool being introduced into the shielding tunnel for final positioning.

4.6 RADIO FREQUENCY CURING

After the tool-part assembly had been positioned on the conveyor belt, masking tape was used to hold the tool in place. Without the tape the polypropylene tool has a tendency to slide out of position as it is cycled back and forth during the cure.

Cure temperatures were measured by infrared fiber optics. The thermal monitoring system was aligned with the sighting ports on the side of the tool. These ports were assigned numbers 1 to 6 as the tool passed through the rf field left to right.

The sensing probe was positioned through the oven wall to within three inches of the laminate. The end of the probe was aligned to sight through the port on to the midplane of the edge of the laminate. The probe is connected outside the oven to the detecting head which in turn transmits the signal to a digital readout calibrated in a direct fahrenheit degrees. An x-y strip chart was also connected to the digital readout. See Figure 30.

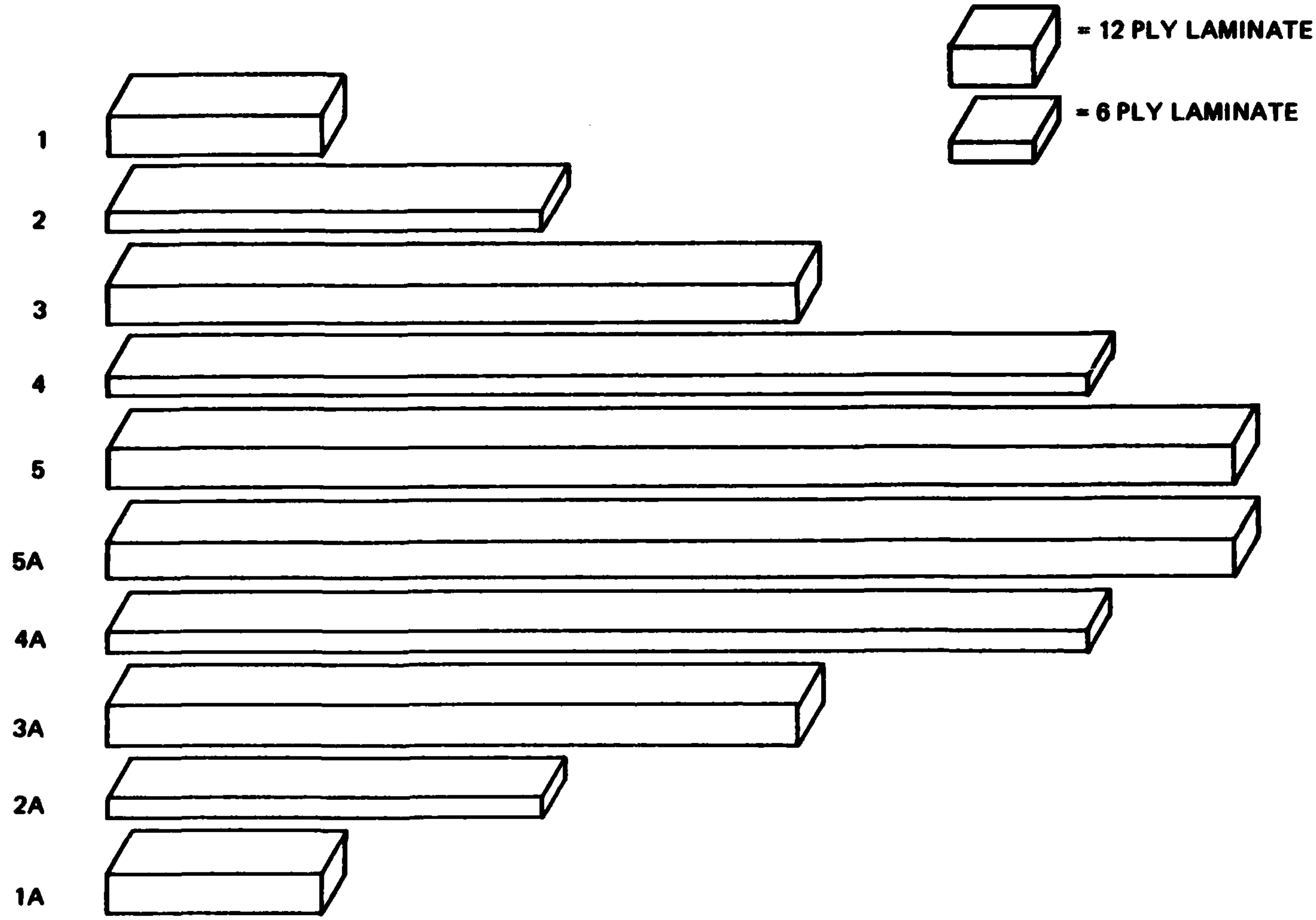


Figure 12. Exploded View of the Wedge Section

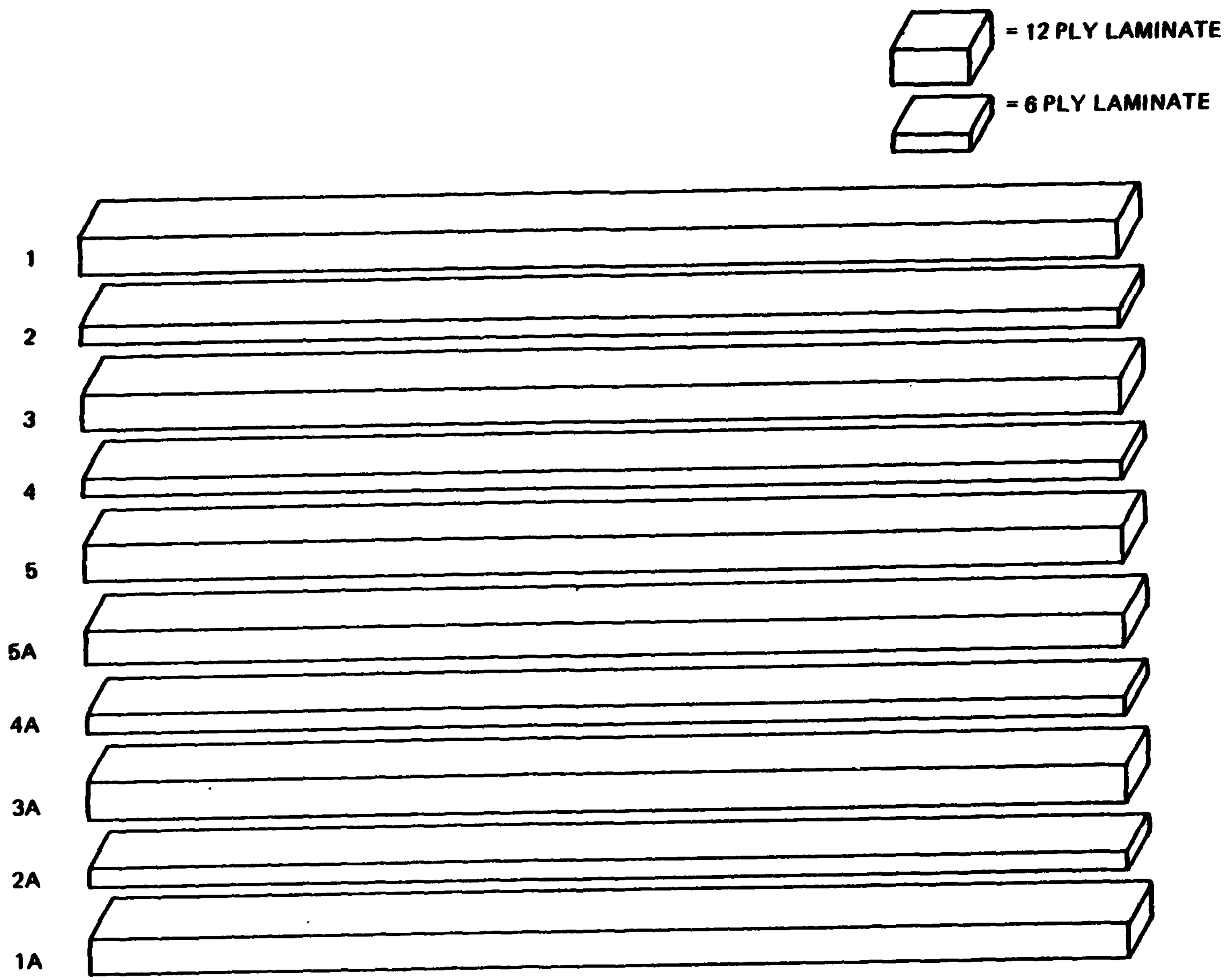


Figure 13. Exploded View of Constant Thickness Section

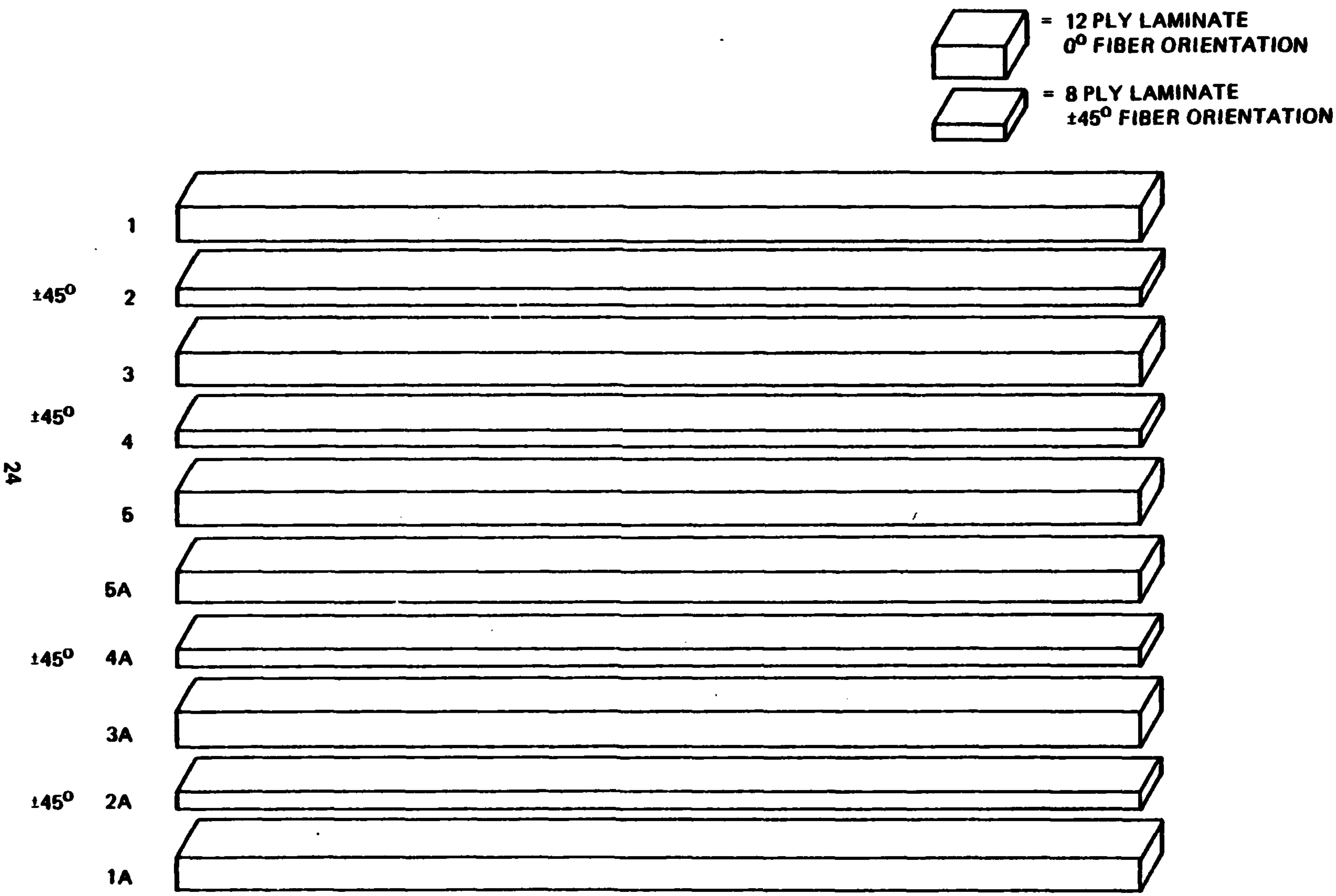


Figure 14. Exploded View of Constant Thickness Section of 8 Ply ±45° Fibers

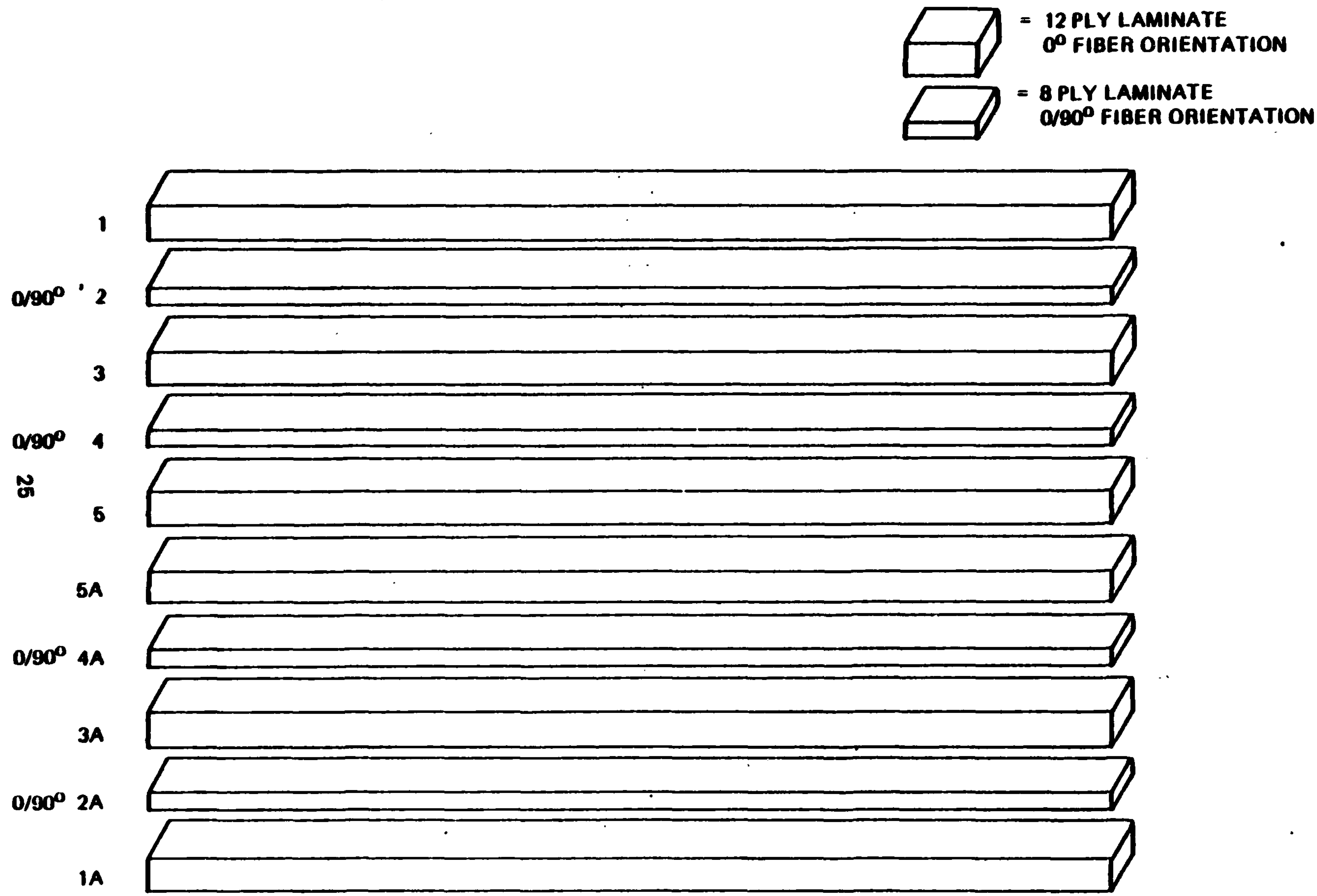


Figure 15. Exploded View of Constant Thickness Section of 8 Ply 0/90° Fibers

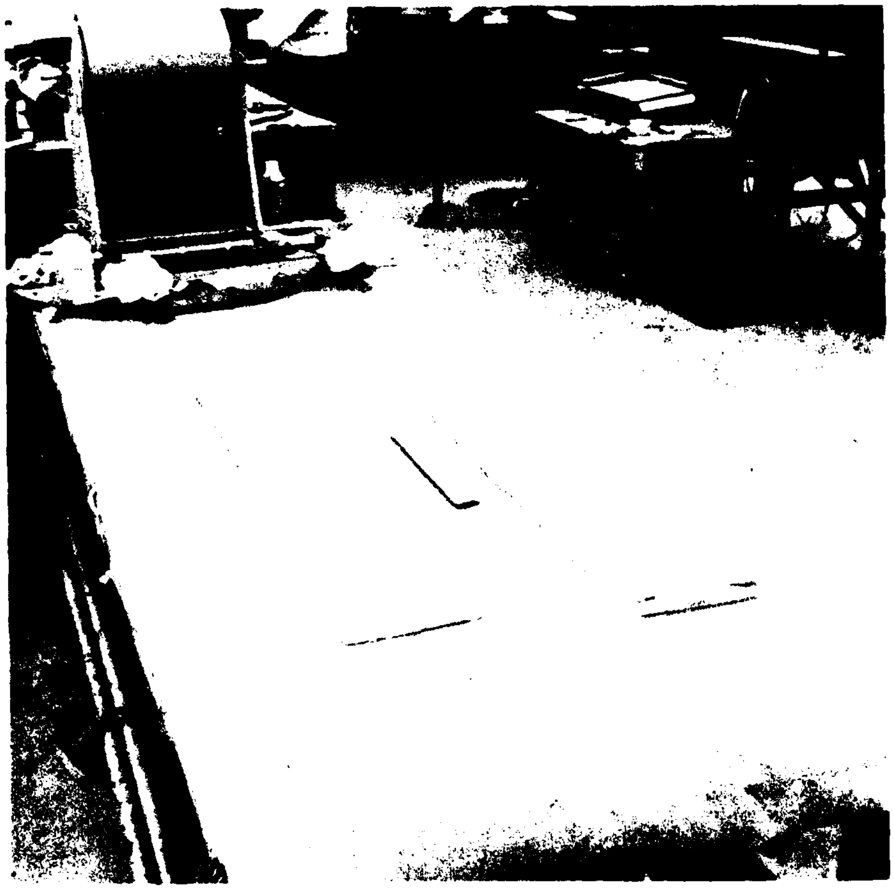


Figure 16. Final Unit Ready to be Located

Figure 17. Application of Final Unit to Laminate

Figure 18. Placing Fiberglass Bleeder

Figure 19. Application of Nylon Bag

Figure 20. Final Teflon Seal Bag

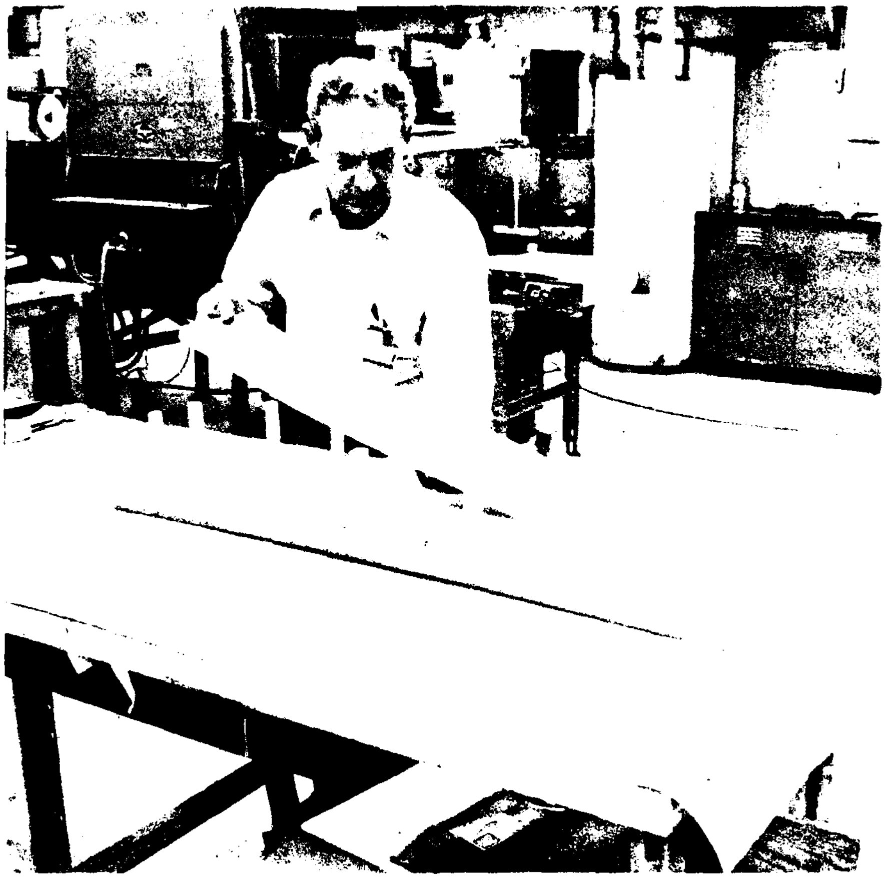


Figure 21. Bagged Laminate Placed in Tool

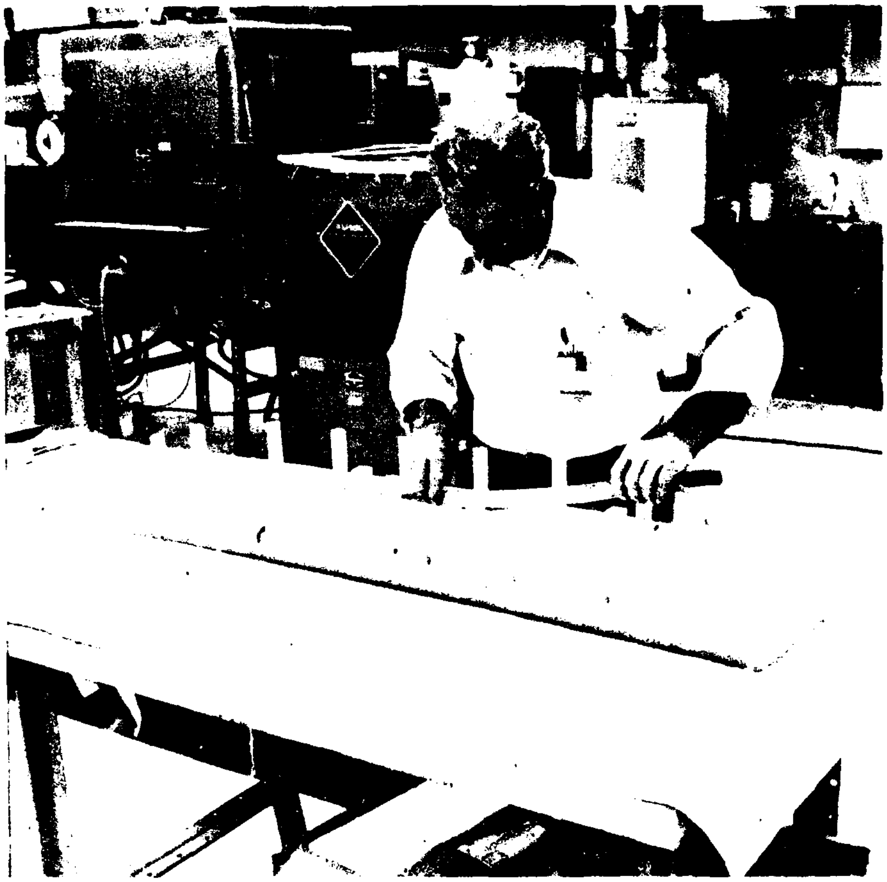


Figure 22. Silicone Rubber Spacers Located in Side of Tool

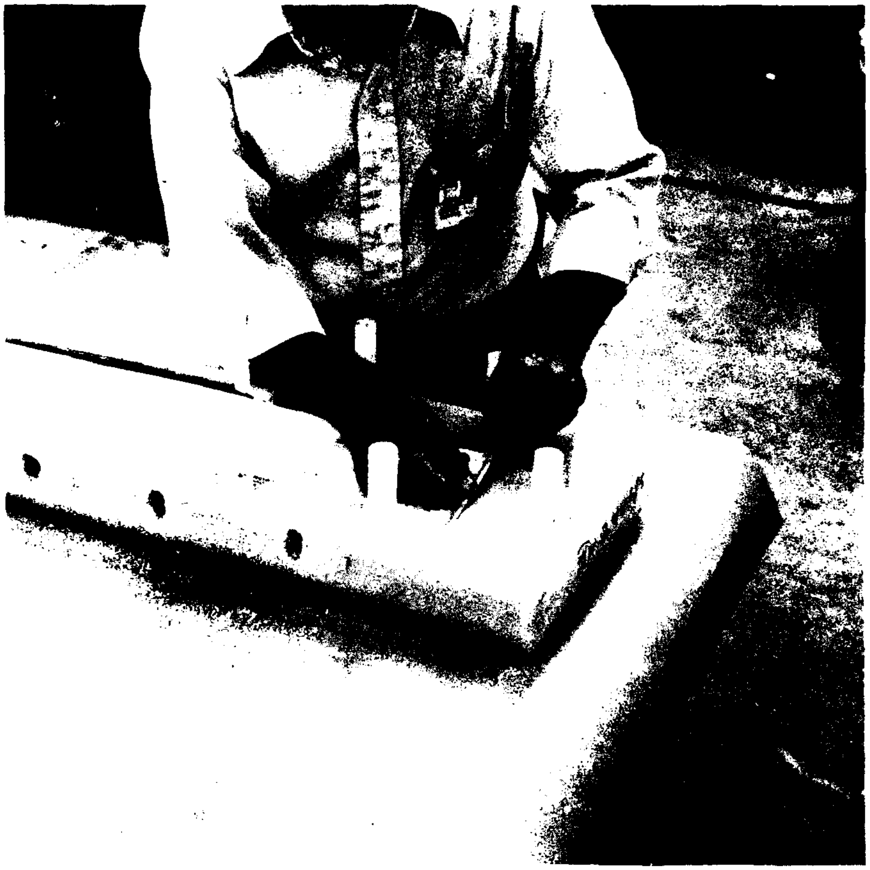


Figure 23. Silicone Rubber Spacers Located in End of Tool

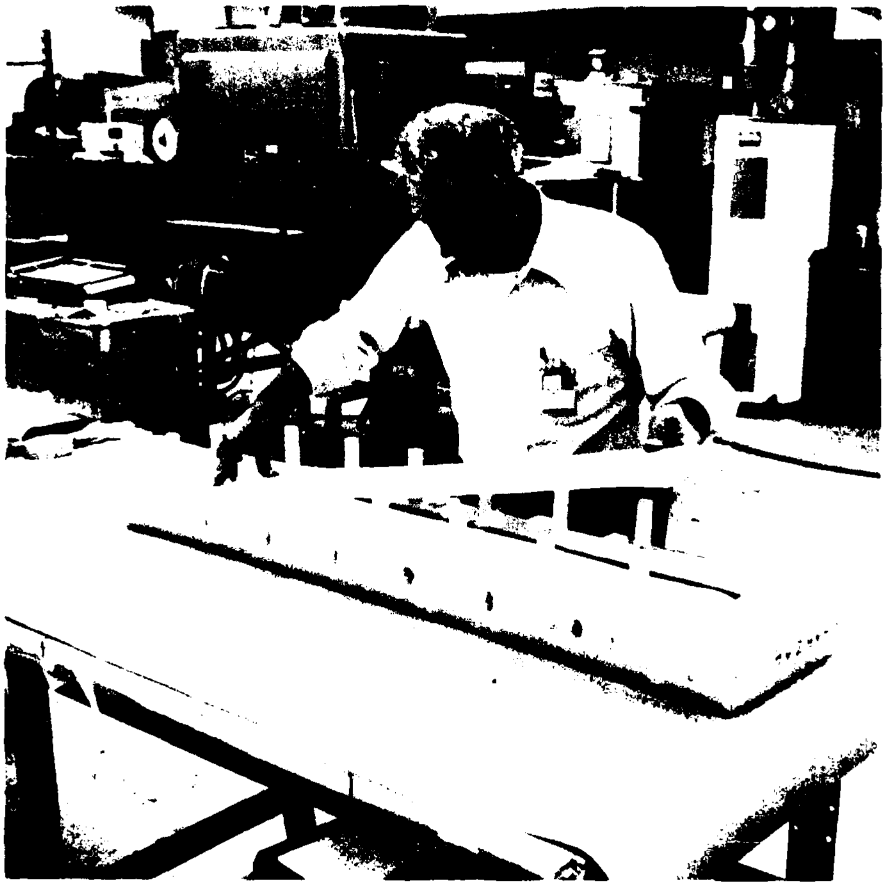


Figure 24. Polypropylene Spacer Being Located

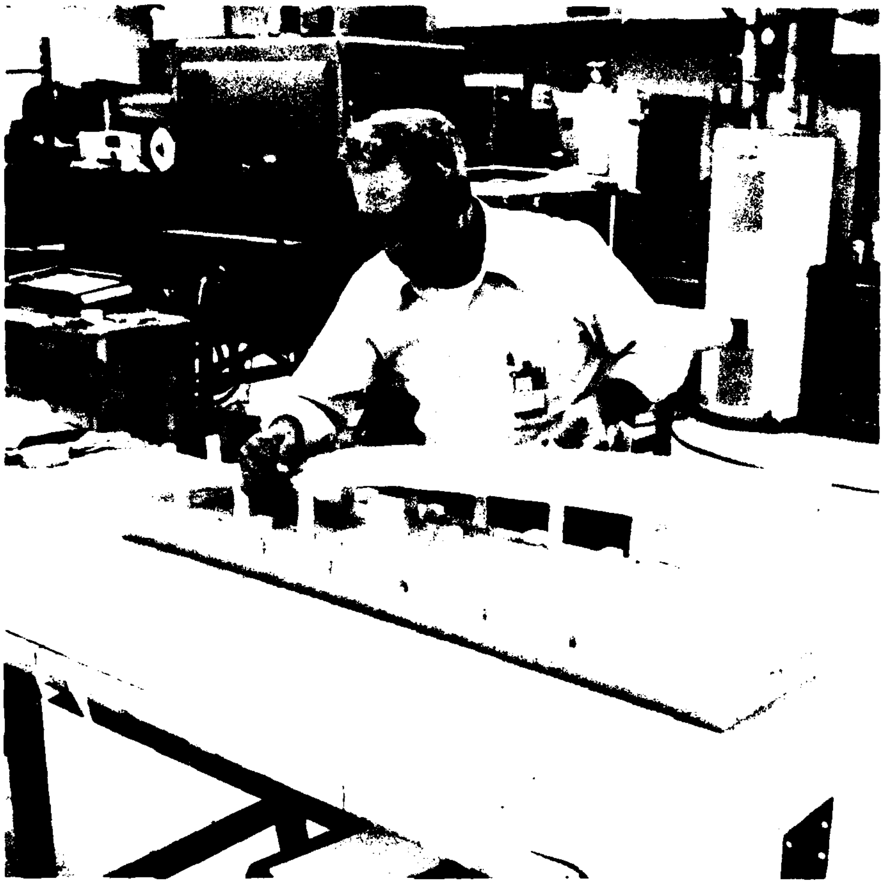


Figure 25. Application of Pressure Plate

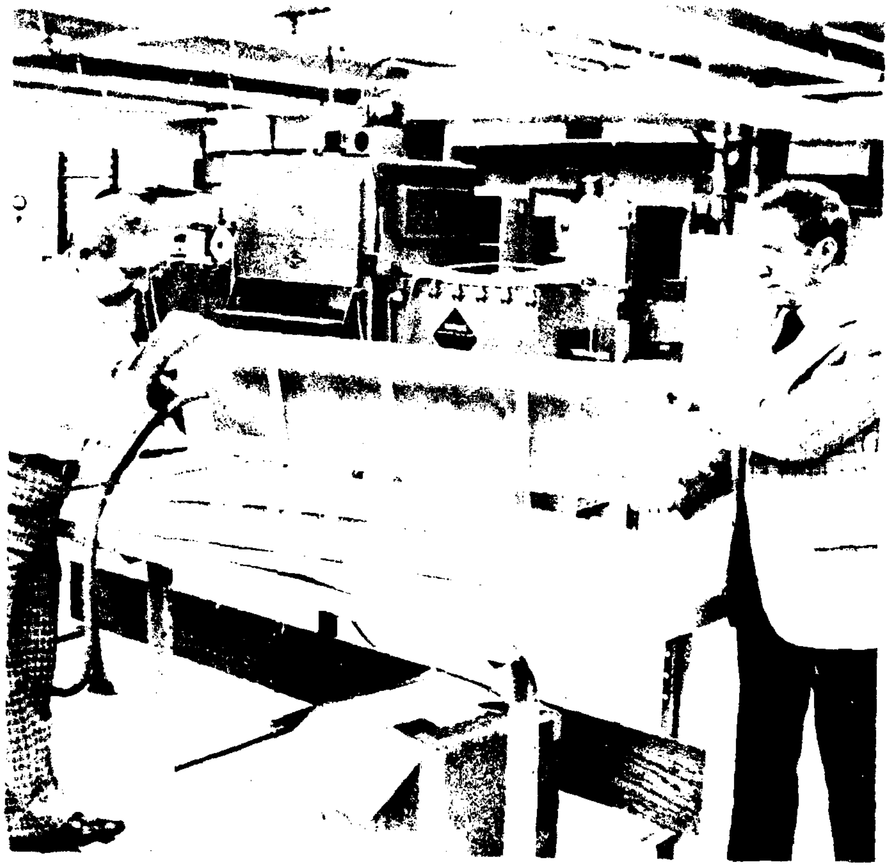


Figure 26. Positioning Top Section of Tool Containing Silicone Pressure Bag

Figure 27. Tooling Sections Being Secured

Figure 28. Resin Containment Bag is Pierced

Figure 29. Assembled Tool Introduced Into RF Unit

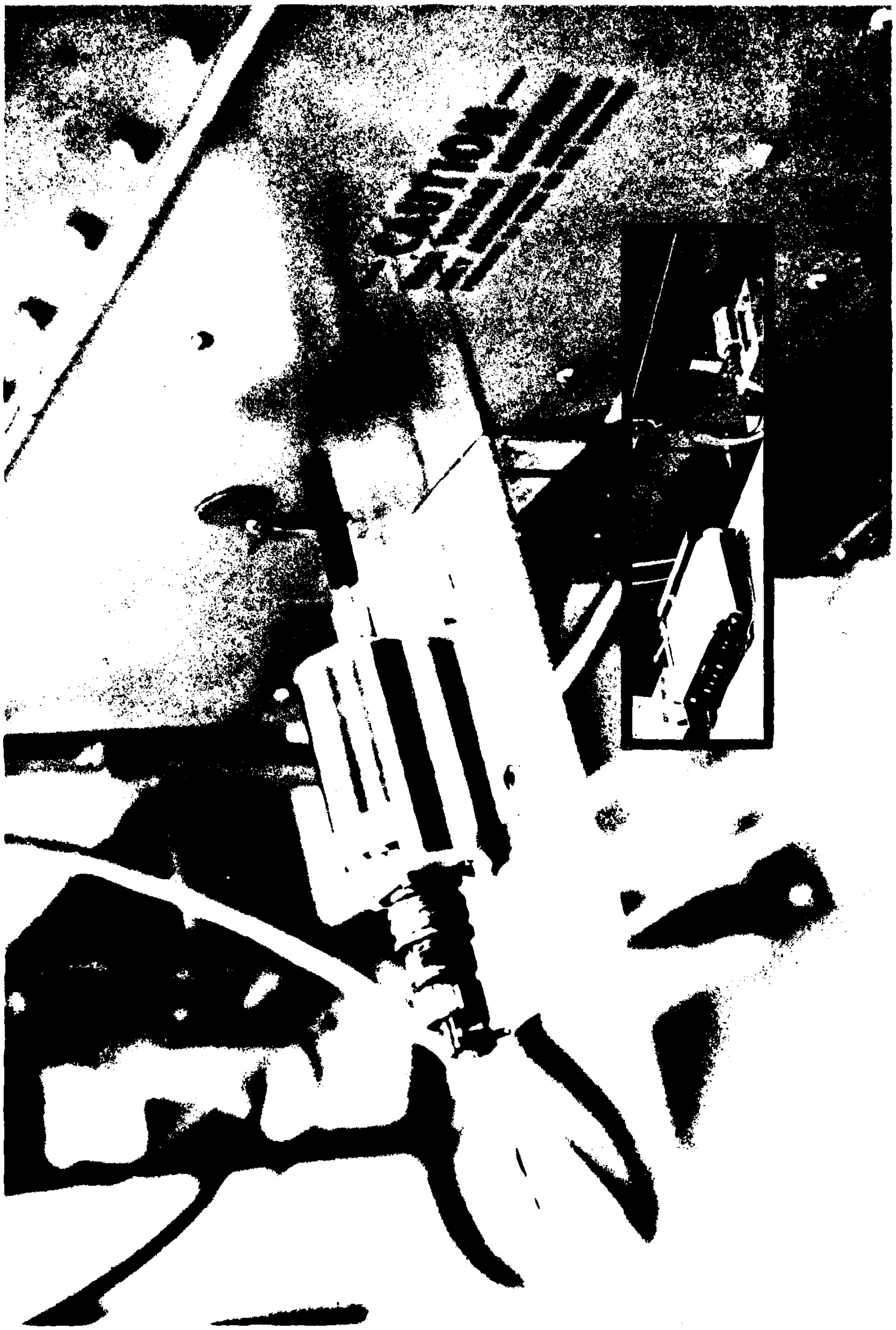


Figure 30. Detector Head and X-Y Strip Chart Recorder

A whip antenna was located in the vicinity of the front access door and connected to a 250 megahertz 8-digital frequency counter to monitor frequency during the cure.

Once the assembled tool was secured to the conveyor, the part was cured by cycling the assembly through the rf field between properly spaced electrodes at a controlled speed. For constant thickness sections the temperature of the laminate increased incrementally to 250°F over a 70 minute period. For wedge sections the temperature increase developed over a period of 120 minutes. For all laminate cures, however, 30 to 40 psig pressure was applied when the laminate temperature ranged from 170°F to 200°F. The dielectric heating was monitored throughout the cure and changes in the temperature of the laminate were recorded on the x-y strip chart. Charts for each run are presented in Appendix E.

Monitoring the cure of the constant thickness sections presented no particular problem. Due to the even thickness of the laminate, temperature increases were evident within 10 to 15 minutes of exposure to the rf field.

In the case of the wedge shaped laminates, monitoring the temperature at the thin edge of the wedge is somewhat difficult. Reference to the temperature readout charts for wedge sections (Appendix E) shows the aborted pen tracing for sight ports Numbers 1 and 2; the vicinity of of the thin position of the wedge. In the early cures, before the transparent film was used to contain the resin, resin build up at the ports also contributed to erratic temperature measurements. Although the film helped, temperature measurements at the thin end of the laminate were still erratic.

Early in the curing effort it was found that the last one to two inches of thin end of the wedge were not curing. Experience showed that the tapered portion of the wedge, up to one half the length, required longer exposure to the rf to complete the cure. Thus, a process was adopted whereby only the thinner portion of the wedge, to one half the length, was exposed to the field for the first thirty minutes of the run; the rf was switched off as the thicker portion of the wedge passed between the electrodes. After this initial exposure the entire laminate was allowed to cycle through the field for the remainder of the cure. It was also necessary, in some instances, to allow portions of the laminate to be exposed to a static application of the rf for periods of one to two minutes.

4.7 PROCESSING PARAMETERS

As more experience was gained through each succeeding cure it was found that plate current, grid current, filament voltage and line voltage remained constant for a specific load passing through the field at a particular electrode spacing. Also, appropriate electrode spacing for most of the cure, resolves itself to a clearance of the upper electrode from the top surface of the tool of approximately one half inch. Indeed, in instances where the temperature increase proved to be too rapid, control was exerted by increasing the space between the electrodes to reduce the energy input or the rf was turned off while a particular section of the assembly passed through the electrodes.

Actually, processing parameters resolved themselves, for the most part, to electrode spacing and the intermittant application of the rf field. Acceptable belt speeds proved to be between four to five feet per minute. With early runs a seven second delay at each end of the cycle was used. This was later reduced to one second.

Individual temperature measurements taken at each sighting port were automatically recorded on the xy-strip chart recorder with each pass through the field. Temperature data and processing parameters for each cure are presented in Appendix F. The numbers for grid current and filament voltage represent load and no load conditions. For grid current, high numbers represent no load condition and low numbers a load condition and vice versa for plate current.

4.8 TESTING PROGRAM

4.8.1 Contract Items

Contract requirements specified the rf cure of five wedge sections and five constant thickness sections with subsequent shipment of these sections to the Army Materials and Mechanics Research Center (AMMRC), Watertown, Ma.

Testing of specimens from various positions through the cross-section of the rf cured composite was to include but not be limited to hardness, tensile strength, short beam shear, and flexure. Also, test specimens of a quantity not less than that specified in the approved internal specification were to be prepared and shipped to AMMRC.

In the course of the program, 24 rf cures were conducted resulting in 11 wedge sections and 13 constant thickness sections. Table 4 lists pertinent information on each laminate and the disposition of each. It will be noted that Table 4 numbers start with number 14. Cures prior to this were conducted under the earlier IR&D in-house effort. The ten sections required for AMMRC were packaged and sent the 12th of December 1979 to Watertown, Ma. Also, individual test specimens for AMMRC were prepared by the Cincinnati Testing Laboratory and shipped directly to AMMRC.

4.8.2 Testing Results

Cincinnati Testing Laboratories, Inc. 417 Northland Road, Cincinnati, Ohio, 45240, contracted to cut, machine, and conduct the testing for the prepregged material and the rf cured laminates in accordance with the requirements of BMS-8-196A.

The quality of the first three rf cured wedge sections was evaluated at Boeing Vertol by measuring the flexural strength and modulus at room temperature, Barcol hardness, and resin content. These data are presented in Table 5.

TABLE 4. SUMMARY OF CURE SEQUENCE AND PANEL DISPOSITION

Cure Number	Wedge Units	Constant Thickness Section	Cure Date	Unit Disposition
14	1st	–	5-22-79	Used for preliminary in-house testing.
15	2nd	–	5-29-79	Used for preliminary in-house testing.
16	3rd	–	6-8-79	Shipped to AMMRC.
17	–	1st	6-14-79	Discarded – Fiber displacement washing in all panels.
18	4th	–	6-21-79	Sent to Cincinnati Testing Lab for specimen preparation and test.
19	–	2nd	6-27-79	Sent to Cincinnati Testing Lab for specimen preparation and test.
20	5th	–	7-17-79	Discarded – Fibers of several panels distorted – uneven pressure.
21	–	3rd	7-23-79	Shipped to AMMRC.
22	6th	–	7-25-79	Shipped to AMMRC.
23	–	4th	8-22-79	Shipped to AMMRC.
24	7th	–	8-24-79	Sent to Cincinnati Testing Lab for specimen preparation and test.
25	–	5th	8-31-79	Sent to Cincinnati Testing Lab for preparation of AMMRC test specimens.
26	8th	–	9-5-79	Sent to Cincinnati Testing Lab for preparation of AMMRC test specimens.
27	–	6th	9-10-79	Lost in transit.
28	–	7th	10-23-79	Shipped to AMMRC.
29	–	8th ($0/90^{\circ}$)	11-5-79	Sent to Cincinnati Testing Lab for specimen preparation and test.
30	–	9th ($\pm 45^{\circ}$)	11-2-79	Sent to Cincinnati Testing Lab for specimen preparation and test.
31	–	10th ($\pm 45^{\circ}$)	11-6-79	Sent to Cincinnati Testing Lab for preparation of AMMRC test specimens.
32	–	11th ($0/90^{\circ}$)	11-9-79	Sent to Cincinnati Testing Lab for preparation of AMMRC test specimens.
33	–	12th	11-13-79	Shipped to AMMRC.
34	9th	–	11-15-79	Shipped to AMMRC.
35	–	13th	11-21-79	Shipped to AMMRC.
36	10th	–	11-27-79	Shipped to AMMRC.
37	11th	–	11-29-79	Shipped to AMMRC.

TABLE 5. QUALITY MEASUREMENTS OF FIRST THREE WEDGE SECTIONS

Test	Wedge Section 1	2	3	BMS 8-196A
Flex Strength psi x 10^6	183.0	189.7	188.1	160.0 min
Flex Modulus psi x 10^6	6.69	6.2	5.5	5.3 min
Barcol Hardness	68.74	66.70	70.75	Not required
Resin Content % (Cured Laminate)	26.8	25.6	25.8	Not required

Based on these results the fourth wedge and the second constant thickness section were sent to Cincinnati for test. Prior to shipment, the laminates were trimmed to size and separated into the individual panels. The separations were made at the peel ply layer. Due to the compaction of the laminate these separations were not made without some difficulty and care had to be exercised to prevent some fiber delamination. The separations were started at one end of the laminate (where a small piece of teflon had been inserted between each set of panels before cure) by using a thinned back-edge of a hack saw blade. When an adequate opening had been made, a 12-inch metal rod one inch in diameter was inserted and the separation continued by rolling the rod down the length of the panel.

Diagrams were prepared to represent each panel and to locate and identify the individual test specimens. These diagrams are presented as Appendix G.

Early test results on the panels sent to Cincinnati showed that the flexural strength/modulus at 180°F were below specification requirements (126 ksi/4.3 msi vs 140 ksi/5.2 msi). Also, short beam shear results at room temperature were below requirements (9,000 ksi vs. 10,000 ksi). Detailed test results are presented as Appendix H. Review of these results and the curing parameters suggested that these lower values could be due to the relatively low (30 and 35 psig) pressures used on the laminates during the cure. Testing was terminated on the specimens from wedge section number 4 and constant thickness section number 2. A new wedge section (number 7) and constant thickness section (number 6) were sent to Cincinnati as replacements to provide a new set of test specimens. These new sections had been cured at 40 psig pressure to upgrade the mechanical properties. Compacting pressures were kept in the 30 to 40 psi range because creep and deflection of the polypropylene tooling would be more prevalent under greater stress at cure temperature and the stud strength may have been exceeded.

4.8.3 Discussion of Results

The quality of the prepreg material, SP-250-E-33-W-456, Lot 7, Jumbo 50 was measured under paragraph 5.1 of BMS-8-196A but limited to those properties specified in Table one. The physical properties of the press cured laminates were measured in accordance with the requirements of Table two of specification BMS-8-196A.

The mechanical properties of the laminates cured by the Radio Frequency Process were determined with reference to property requirements specified in Table three of BMS-8-196A. Although the BMS-8-196A relates to material qualification and not to process evaluation it is considered useful for evaluating the mechanical properties of the rf cured laminates.

4.8.3.1 Prepreg Properties

A summary of the properties of the prepreg material is presented in Table 6. These results show that the material meets the requirements of BMS-8-196A with the exception of Resin Flow. This property averaged at 5.5 percent which is somewhat below the minimum 9 percent specified. (This fall-off, however, may be attributed to a four month interval between the time the material was received and the testing.) Also, gel time data were not determined because sufficient resin could not be removed from the prepreg. This in turn could be due to the age of the prepreg. In general, however, the material portrays the properties reported in the 3M certification report. Detailed test results for the prepreg properties are presented in Appendix I.

4.8.3.2 Press Cured Laminate Physical Properties

One each of 5-ply and 12-ply laminates, twelve inches square, of the SP250 material were press cured in accordance with paragraph 5.2 of BMS-8-196A. Cure conditions were 120 ± 10 minutes at 255°F ± 5°F and 40 PSIG pressure. The laminates were post cured 90 minutes at 255°F without pressure. The properties of these laminates were determined in accordance with paragraph 5.2.2 of the specification. A summary of the results is given in Table 7.

With the exception of the void content of the 12 ply laminate, the properties are within the requirements of the BMS and agree with the values contained in the 3M certifying report. Detailed test results are presented as Appendix J. In addition to a determination of the above properties both the flexural strength/modulus and the tensile strength/modulus were determined for these laminates. These values are presented in Tables 8 and 9. The values are lower than those reported in the 3M certifying report although they do meet the requirements of the BMS-8-196A, Table III.

4.8.3.3 Rockwell Hardness

Both the wedge section and the constant thickness section panels cured by Radio Frequency were examined to measure the degree of cure. Utilizing the "M" scale, the Rockwell Hardness for each panel was determined. A cured rigid epoxy resin gives Rockwell M readings[6] in the neighborhood of 100. A summary of the Rockwell Hardness values is presented as Table 10. Values for the 12-ply laminates give evidence of a full cure condition in all instances except no. 3 panel of the constant thickness section. All the 6 ply laminate values, however, suggest that additional cure may be necessary. All these values are an average of ten measurements and the detailed test results are given in Appendix K.

TABLE 6. SUMMARY/PREPREG PROPERTIES

Property	Required	Actual
Volatile Content, Max (%)		
Average Value	0.6	0.37
Individual Value	0.8	0.47
Resin Content, Avg (%)	30–36	31.2
Ply Thickness, Mils	9–11	9.4–10.0
Glass Weight, Avg Grams per ft^2	25.2–27.6	26.30
Total Weight, Avg Grams per ft^2	36.25–42.55	38.45
Gel Time, Minutes (Min)	33	N/A
Resin Flow, (%) Avg Value	9–17	5.52

TABLE 7. SUMMARY/LAMINATE PHYSICAL PROPERTIES

Property	Allowable	Actual	
		5 ply	12 ply
Void Content, Max (%)	3.5	0.6	3.9
Fiber Content, Avg (%)	Report	58.8	50.5
Resin Volume, Avg (%)	Not Required	40.6	45.6
Composite Density, Avg $lb/in.^3$	Report	0.072	0.067
Resin Content, Avg (%)	Not Required	25.5	30.9
Ply Thickness, Mils	8.5 ± 1.0	9.4	8.9

TABLE 8. FLEXURAL STRENGTH

CUSTOMER: Boeing Vertol Company

Date: January 21, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50 *

Support radius: 1/8"

Specification: BMS 8-196A

Nose radius: 1/8"

Pre Conditioning: 40 Hrs./23°C/50% R.H.

Test Speed: .04 in./min.

Test Condition: 23°C/50% R.H.

Specimen length: 4"

Span (L) 1.6 L/d Ratio: 16/1

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3 m}{4 bd^3}$

* Panel Fabricated at Cincinnati Testing Labs., Inc.

S = flexural strength in psi

E_B = Modulus of elasticity in psi x 10^6

P = Break load in lbs.

b = specimen width in inches

d = depth of beam in inches

L = span in inches

m = initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (psi)	d (in.)	b (in.)	P (lbs.)	m (lbs./in.)	E_B (psi x 10^6)
1	157,490	0.102	0.996	680	5530	5.36
2	162,030	0.101	0.999	688	5674	5.64
3	161,800	0.102	0.998	700	5674	5.49
4						
5						
Avg.	160,440	.102				5.50

TABLE 9. TENSILE STRENGTH/MODULUS

CUSTOMER: Boeing Vertol Company

Date: January 21, 1980

Material: SP 250-E-33 W-456, Lot 7, Jumbo 50*

Specification: BMS 8-196A

Pre Conditioning: 40 Hrs./23°C/50% R.H.

Testing Speed: .05 in./min.

Test Condition: 23°C/50% R.H.

Specimen Type: Figure 5

S = Ultimate Tensile Strength in PSI

Sy = yield strength in PSI

Et = modulus of elasticity in PSI x 10^6

P = break load in lbs.

b = specimen width in inches

d = specimen thickness in inches

Y = strain in in./in.

Tensile Strength (S) = $\frac{P}{bd}$

Modulus of Elasticity (Et) = $\frac{P}{bdY}$

* Panel fabricated at Cincinnati Testing Labs., Inc.

Specimen (no.)	S (PSI)	S_Y (PSI)	P (lbs.)	d (in.)	b (in.)	Et (psi x 10^6)	Elongation (%)
1	150,320		3340	0.044	0.505	6.38	
2	151,880		3570	0.046	0.511	6.43	
3	136,650		3130	0.045	0.509	7.66	
4	136,400		3200	0.046	0.510	6.99	
5							
Avg.	143,810					6.87	

TABLE 10. SUMMARY OF ROCKWELL HARDNESS VALUES (AVERAGE)

Panel (No.)	M-Scale	6 Ply	12 Ply
1	Constant Thickness Section	–	96
2	Constant Thickness Section	74	–
3	Constant Thickness Section	–	79
4	Constant Thickness Section	83	–
2	Wedge Section	83	–
2A	Wedge Section	70	–
3	Wedge Section	–	96
3A	Wedge Section	–	96
4	Wedge Section	82	–
4A	Wedge Section	89	–
5	Wedge Section	–	97
5A	Wedge Section	–	96

4.8.3.4 Fatigue Properties of rf Cured Laminates

A summary of Fatigue Properties is presented in Table 11. Detailed specimen testing and a plot of the number of cycles versus the alternating stress is given in Appendix L. Data developed in the Boeing Vertol "E" glass Qualification program for SP250E is also plotted for comparison. The data for the rf cured laminates falls slightly below that plotted for the press cured laminates. This could be attributed to an under cured resin matrix or, additional pressure may be needed during the cure.

TABLE 11. SUMMARY/FATIGUE PROPERTIES

0^{o} Fiber Orientation

	Number of Cycles	
	Specimen No. 1	Specimen No. 2
Alternating Stress (ksi)		
22	7,887,000	4,251,000
28	374,000	103,000
32	9,000	2,000
36	6,000	3,000

$\pm 45^{o}$ Fiber Orientation

	Number of Cycles	
	Specimen No. 1	Specimen No. 2
Alternating Stress (ksi)		
22	10,088,000	12,809,000
28	3,875,000	1,532,000
32	552,000	1,370,000
36	30,000	45,000

4.8.3.5 Laminate Mechanical Properties

The mechanical properties of the rf cured laminates were determined at three test temperatures −65°, 74° and 180°F after exposure to three hostile environments; oil soak, boiling water and a 180°F soak, as detailed in BMS-8-196A. A summary of these results is given in Table 12. Underlined results are below required value.

TABLE 12. SUMMARY/LAMINATE MECHANICAL PROPERTIES

Property	Test Temperature					
	−65°F		74°F		180°F	
Beam Shear (KSI)	Averages					
	Req	Act.	Req	Act.	Req	Act.
Control	14.0	12.40	10.0	10.18	7.5	7.33
Oil Soak	14.0	11.90	11.0	9.47	7.5	7.84
Water Boil	13.0	12.61	10.0	8.53	7.5	5.95
Temp Exposure	14.0	12.20	11.0	10.28	7.5	8.18
Flexural Strength (KSI)/ Modulus (MSI)						
Control	192/5.2	264/5.5	160/5.3	191/5.4	130/5.2	156/5.7
Oil Soak	190/5.2	250/5.5	160/5.3	189/5.7	130/5.2	157/5.9
Water Boil	192/5.2	238/4.9	145/5.3	186/5.7	124/5.2	105/4.8
Temp Exposure	192/5.2	228/5.0	165/5.3	183/5.3	140/5.2	137/5.3
Tension (KSI)/Modulus (MSI)						
Orientation						
0°	165/–	162/6.8	140/5.5	134/6.4	122/5.5	111/6.1
0°/90°	85/–	76/4.2	62/3.5	70/3.7	60/3.1	64/3.4
± 45°	20/–	21/2.7	21/1.8	19/2.1	20/1.4	19/1.6

Req = Required Act. = Actual

4.8.3.5.1 Beam Shear – Examination of the average values for beam shear show the majority falling slightly below values specified in the BMS-8-196A; the percentage fall-off ranging from 3 to 20 percent. The water boil exposure proved to be the most severe environment for the beam shear specimens. In light of the flexural results, the lower beam shear values seem a paradox. Based on Rockwell Hardness, the degree of cure appears acceptable. Also, the source of the specimen (wedge or constant thickness section), its location in the panel, or the stacking location of the panel in the section seem to have no relationship to individual mechanical property values.

4.8.3.5.2 Flexural Strength/Modulus – The flexural modulus of specimens tested at −65°F and 180°F after being subjected to the water boil were lower than values required for specification BMS-8-196A. It is noted also that the flexural strength reported for those specimens tested at 180°F after water boil was also below the specification requirements.

4.8.3.5.3 Tensile Strength/Modulus – Examination of the values for unidirectional (0°) laminates show them to be within the acceptable 5% of the specified values with the exception of the measurement at 180°F which portrays a 9.0 percent reduction. The tensile strength values relate directly to the laminate resin content. A "range of acceptable tensile strength values as a function of resin content" for the room temperature test is given as Figure 6, page 29 of the BMS-8-196A. It should be noted also, the Rockwell Hardness values for the 6-ply laminates ranged from 70 to 90 versus an acceptable 100 value. This suggests that some additional cure was required.

Both the 0/90 and the ±45° tensile strength values evidenced slight fall-off from the specification requirements. The values for the 0/90 at –65°F is low by 10 percent but the 74°F and 180°F test results are acceptable. For the ±45° tensile values the 74°F test result is 9.5 lower than the specification requirement. Although the values for the ±45° tensile results are underlined to show they are below requirement, they are within an allowable 5 percent deviation and thus considered acceptable. Detailed test results are presented in Appendix M.

To resolve the differences in results for Flexural, Short Beam Shear and Tensile properties a series of retests was conducted. These results are discussed below.

4.8.3.5.4 Retest Data – Additional testing was conducted on rf cured panels which were subjected to post cure at 250°F for 16 hours. Also, the resin content was determined for those post cured panels used to re-evaluate tensile strength/modulus. Summary retest values for the post cured mechanical properties are given in Table 13 and the resin content values are listed in Table 14.

A comparison of the results in Table 13 with original test values shows improvement in Flexural strength at 180°F and in Tensile strength/modulus for 0/90° fiber orientation at –65°F. Other values for short beam shear and tensile strength show no significant improvement. These results suggest that the degree of cure provided by rf energy was relatively complete.

The resin content for panels used for tensile test specimens were wide spread, ranging from 20 to 28%. This variation is difficult to explain since all panels were subjected to 40 psig pressure during cure.

Detailed resin content values and retest values for mechanical properties are provided in Appendix N.

4.8.3.5.5 Panel Analysis – Two areas that may be scrutinized further are the ultimate cure pressure and the physical separation of the individual panels from each other. A pressure greater than 40 psig may be required to realize a beam shear strength commensurate to press cured laminates. Also, it is suggested that the 40 psig pressure may not have been sufficient to produce low void 12 ply laminates. Although the void content of the radio frequency cured laminates was not determined in this program, reference is made to the press cured laminates (para 4.8.3.2) wherein the 40 psig cure pressure resulted in 12 ply laminates with 3.9 percent void content. Thus, a high void content would directly relate to a fall off in short beam shear strength. Separation of the panels from each other was not easily accomplished although peel

ply had been used as a release agent. Some force was required on the round bar that was used as a wedge between the panel being removed and the remainder of the section. It may be that some fibers were disturbed or slightly prestressed during this separation procedure. It is expected, however, that the rf cure of a composite component for a helicopter would not entail a separation process as described here.

TABLE 13. RETEST SUMMARY/LAMINATE MECHANICAL PROPERTIES

Property	Test Temperature					
	-65°F		74°F		180°F	
Beam Shear (KSI) 0°	Averages					
	Required	Actual	Required	Actual	Required	Actual
Control	14.0	11.2	10.0	–	–	–
Oil Soak	14.0	13.2	11.0	9.8	–	–
Water Boil	13.0	–	10.0	8.8	7.5	5.7
Flexural (KSI) 0° Modulus (MSI)						
Water Boil	–	–	–	–	124/5.2	128/4.8
Tension (KSI)/ Modulus (MSI						
Orientation						
0°	–	–	–	–	122/5.5	112/5.9
$0^{\circ}/90^{\circ}$	85/	90/4.2	–	–	–	–
$\pm 45^{\circ}$	–	–	21/1.8	20/2.2	–	–

TABLE 14. RESIN-GLASS CONTENT

Panel Identification	Run No.	Percent Resin Content	Percent Glass Content
Constant Thickness Section			
No. 4	No. 25	20.8	79.2
No. 2	No. 25	20.0	80.0
Wedge Sections			
No. 4	No. 24	28.1	71.9
No. 4A	No. 24	25.4	74.6
No. 2A	No. 24	21.6	78.4
No. 2	No. 24	27.8	72.2

5 CONCLUSIONS

5.1 The feasibility of conveyorized rf cure of epoxy/fiberglass composite has been demonstrated. For practical purposes the mechanical properties of rf cured composites are commensurate with requirements of the Boeing Material Specification.

5.2 The use of a stronger tooling material (i.e., polysulfone) will allow the application of greater pressure during the cure and thus improve the interlaminar shear properties.

5.3 RF cure can be applied to specific helicopter composite hardware limited only by equipment design and part geometry.

6 RECOMMENDATIONS

Based on the findings reported herein, it is recommended that the investigation of conveyorized rf cure of resin/fiberglass composites be continued.

A follow-on effort should be directed toward the fabrication, cure and service life testing of a specific composite helicopter structure. It is recommended that tooling for rf curing be made of polysulfone. It is superior to polypropylene in strength and stiffness, has minimum creep, and is capable of withstanding 300 to 350°F temperatures.

REFERENCES

1. J. Mahon, et al; "Manufacturing Methods for Rapidly Curing High-Temperature Components," AFML-TR-73-159, August 1973.

2. M. Rothstein, "Dielectric Heating," Encyclopedia of Polymer Science and Technology, V. 5 II, 1–23, 1966.

3. J. W. Cable, "Induction and Dielectric Heating", Reinhold Pub. Corp. 1954.

4. "Optimized Dielectric Curing and Tooling for Primary Composite Structure", Boeing Vertol Company, CAP-6302, D210-10814-1, June 1974.

5. "Conveyorized Radiofrequency Oven for Curing Epoxy/Fiberglass Composites," Boeing Vertol Company, D210-11461-1, December 1978.

6. Lee, H. and Neville, K., "Handbook of Epoxy Resins," McGraw-Hill, Inc. 1967, pp 6-31.

APPENDIX A
FINAL TEST PROCEDURE FOR DAAG46-76R-0846
20-KILOWATT RADIOFREQUENCY OVEN

A. Major Electrode Dimensions (22 in. x 35 in.) ____O.K.____
B. Spare Electrode Dimensions (14 in. x 24 in.) ____O.K.____
C. Maximum Electrode Opening (15 inches) ____15 inches____ inches
D. Minimum Electrode Opening (3 inches) ____4 3/16____ inches
E. Minimum Adjustment increment (1/2 inch) ____0.10____ inches
F. Access to electrode via hinged interlocked door ____O.K.____ yes
R.F. applicator inoperable until all doors and panels secured.
G. Power Supply Door open R.F. inoperable ____O.K.____ yes
H. Tube access panel OFF R.F. inoperable ____O.K.____ yes
I. Control panel door open R.F. inoperable ____O.K.____ yes
J. Access door open R.F. inoperable ____O.K.____ yes
K. Left tunnel top unlatched R.F. inoperable ____O.K.____ yes
L. Right tunnel top unlatched R.F. inoperable ____O.K.____ yes
M. Oscillator Tube air cooled ____O.K.____ yes
N. R.F. Cavity has positive venting ____O.K.____ yes
O. Shielded window in the hinged panel allows viewing of load in applicator ____O.K.____ yes
P. Shielded tunnel on either side of cavity ____O.K.____ yes
Power leakage from oven less than 1 MW/cm^2 at the following locations:

Q. Left tunnel ____0.8 (92.6 MHz)____ MW/cm^2 No load 4.375" electrode separation
R. Right tunnel ____1.3 - 1.4 (92.6 MHz)____ MW/cm^2 (0.5)
S. Front Access Door ____0 (92.6 MHz____ MW/cm^2

Left tunnel ____0.30 (94.5 MHz____ MW/cm^2 No load 7.1875" electrode separation
Right tunnel ____0.80 (94.5 MHz____ MW/cm^2 (0.5 amp)
Front Access Door ____0____ MW/cm^2

Left tunnel ____0.7 (92.1 MHz____ MW/cm^2 With load 4.375" electrode separation
Right tunnel ____1.5 (92.1 MHz____ MW/cm^2 (0.8 amp)
Front Access Door ____0____ MW/cm^2

Left tunnel ____5-6 (92.6 MHz)____ MW/cm^2 With load 5.875" electrode separation
Right tunnel ____4-5 (92.6 MHz)____ MW/cm^2 (1.5 amps)
Front Access Door ____0____ MW/cm^2

Left tunnel ____2-3 (93.6 MHz)____ MW/cm^2 With load 9.5625" electrode separation
Right tunnel ____4-5 (93.6 MHz)____ MW/cm^2 (1.7 amp)
Front Access Door ____0____ MW/cm^2

T. Distance between closures on operators side of the tunnel are equal to or less than 6" ____O.K.____ yes
U. Max. Speed of conveyor belt is equal to or greater than 5 ft/min. ____O.K.____ yes
Max Speed ____8.0____ ft/min. with NO load on conveyor. With load of ____322____ pounds on Conveyor the max. speed is ____7.5____ ft/min.
V. Min. speed of conveyor belt is equal to or less than .5ft/min. ____O.K.____ yes
Min. speed ____0.1____ ft/min. with No Load on conveyor. With load of ____322____ pounds on conveyor the min. speed is ____0.1____ ft./min.
W. Conveyor system powered by a DC motor which has a solid state controller ____O.K.____ yes.
X. Entrance and egress from shielded tunnels of work loads shorter than tunnel length possible ____O.K.____ yes

Y. Conveyor has a direction control switch ____O.K.____ yes
Z. Conveyor belt speed indicator is proportional to conveyor speed.
Belt speed indicator ____0.5____ ft/min. No Load
____8.0____ ft/min. No Load
Belt speed indicator ____7.5____ ft/min. Load 153#/ft^2
____0.1____ ft/min. Load

A.A. Control voltage from secondary of isolation transformer 120 volts 60 Hz.
Resistance from secondary voltage side to primary 3 phase line Ø infinite ohms, ØB infinite ohms, ØC infinite ohms.
Secondary low voltage side to primary 3 phase line.
Ø infinite ohms, ØB infinite ohms, ØC infinite ohms.

B.B. 6FU installed External Exhaust now energized O.K. yes.
7FU installed Oscillator Blower now energized O.K. yes.
8FU installed Power Supply Fan now energized O.K. yes.
9FU installed Electrode Motor now moving electrode with main relay energized and filament power on O.K. yes.
10FU installed filament power now on with filament switch on O.K. yes.
12FU installed conveyor motor energized when main relay energized and filament power on and CB-1 on O.K. yes.

In all above fuse tests indication only existed after fuse was installed O.K. yes.

C.C. Line Voltage meter on remote control panel O.K. yes.
Filament Volt Meter on " " " O.K. yes.
Grid Current Meter on " " " O.K. yes.
Plate Current Meter on " " " O.K. yes.
Filament Hour Meter on " " " O.K. yes.
Belt Speed indicator on " " " O.K. yes.
External Dial indicator right of access door O.K. yes.

All switches and pushbuttons actuated by operator on or in Remote Control Panel except Main Disconnect Switch O.K. yes.

D.D. Remove 7FU only. Depress Main Relay pushbutton. Air flow Light extinguished O.K. yes.
Turn Filament Switch ON
Filament voltage indicates zero volts O.K. yes.
7FU installed above indications are reversed and voltage present respectively O.K. yes.

E.E. Overload Mode Switch placed in the "single" position.
Increase power until the plate current meter is in or just enters the red portion of the meter. Observe that R.F. power is removed and that an alarm bell energizes until the R.F. OFF or the EMERGENCY STOP pushbutton is depressed O.K. yes.
Observe that R.F. power is not reapplied O.K. yes.

F.F. Overload Mode Switch placed in the multiply reset position.
Increase power until the plate current meter is in or just enters the red portion of the meter. Observe that R.F. power is removed for 5 seconds then reapplied for three times before the Alarm Bell energizes O.K. yes.

G.G. Depress the R.F. OFF or EMERGENCY STOP pushbuttons Note the Alarm bell deenergizes O.K. yes.

H.H. Depress the R.F. ON or Main Relay and R.F. ON and the sequence in FF is repeated again O.K. yes.

II. Conveyor does not run when turned to the OFF switch position ___O.K.___ yes. Conveyor belt moves toward the left when in the left position ___O.K.___ yes. Conveyor belt moves toward the right when in the right position ___O.K.___ yes. Dwell Timer is adjustable between 0 and 120 seconds ___O.K.___ yes. Turn the switch to the automatic position. Conveyor belt does not move ___O.K.___ yes. R.F. ON pushbutton depressed. R.F. power is applied and the conveyor belt moves left to right ___O.K.___ yes. When conveyor belt right micro switch is actuated the R.F. power is removed, the belt stops and the dwell timer starts ___O.K.___ yes. After the preset time has elapsed the R.F. power is reapplied and the conveyor belt starts moving toward the left ___O.K.___ yes. This cycle continues until the R.F. STOP pushbutton, or the EMERGENCY STOP pushbutton is depressed ___O.K.___ yes.

J.J. With the electrode in the full up position and the R.F. power on record the frequency NO LOAD ___96.06___ MHz.

With R.F. power on lower the electrode to the minimum position and record the frequency ___92.57___ MHz.

K.K. Connect the water calorimeter to the R.F. oven. This water calorimeter consists of the following:

Flow meter*, Input water thermometer*, Output water thermometer*, Supply sewage hoses (furnished by purchaser), R.F. Load Adapter * and special hoses * (* loaned by W.T. LaRose at the time of final approval).

After flow is stabilized record flow ___3.0___ gpm.
Increase R.F. power until maximum plate current is obtained.
Record input water temperature ___22.0___ °C and
output water temperature ___43.5___ °C
Temperature rise between above ___21.5___ °C x 1.8 = ___38.7___ °F
___(3)___ gpm x 8.337 x (___116.1___ °F) = ___967.9___ BTU/min.

___967.9___ BTU/min. x 17.57 = ___17,006___ watts output power into water calorimeter.

After flow is stabilized record flow ___3.0___ gpm.
Increase R.F. power until maximum plate current is obtained.
Record input water temperature ___22.0___ °C and
output water temeprature ___46.5___ °C
Temperature rise between above ___24.5___ °C x 1.8 = ___43.2___ °F.
___(3.0)___ gpm x 8.337 x (___129.6___ °F) = ___1080.4___ BTU/min.

___1084.4___ BTU/min x 17.57 = ___18,983.9___ watts output power into water calorimeter.

After flow is stabilized record flow 3.0 gpm.
Increase R.F. power until maximum plate current is obtained.
Record input water temperature 22.0 °C and
output water temperature 47.5 °C
Temperature rise between above 25.5 °C x 1.8 = 45.9 °F.
3.0 gpm x 8.337 x (137.7 °F) = 1148.0 BTU/min.

1148.0 BTU/min x 17.57 = 20,170 watts output
power into water calorimeter.

After flow is stabilized record flow 3.0 gpm.
Increase R.F. power until maximum plate current is obtained.
Record input water temperature 22.0 °C and
output water temperature 49.0 °C
Temperature rise between above 26.0 °C x 1.8 = 46.8 °F.
(3.0) gpm x 8.337 x (140.4 °F) = 1170.5 BTU/min.

1170.5 BTU/min x 17.57 = 20,565.9 watts output
power into water calorimeter.

APPENDIX B

ELECTROMAGNETIC RADIATION SURVEY REPORT

DEPARTMENT OF THE ARMY
U.S. ARMY COMMUNICATIONS-ELECTRONICS
ENGINEERING INSTALLATION AGENCY
FORT HUACHUCA, ARIZONA 85613

CCC-EMEO-ECD

SUBJECT: Electromagnetic Radiation Survey, 20 KW 90 MHz RF Oven

Commander
Army Materials and Mechanics Research Center
ATTN: DRXMR-AR
Watertown, MA 02172

1. References:

a. Letter, DRXMR-AR, Army Materials and Mechanics Research Center, 29 Sep 77, subj: Electromagnetic Radiation Survey, 20 KW, 90 MHz RF Oven, Boeing-Vertol, Philadelphia, PA.

b. Fonecon between Mr. Sambol, CCC-EMEO-ECD and Mr. Levin, DRXMR-AR, 21 Sep 77.

c. Letter, CCC-EMEO-ECD, USACEEIA, 6 Oct 77, subject as above.

d. Letter, DRXMR-AR, Army Materials and Mechanics Research Center, 19 Aug 77, subject as above.

2. Reference 1d was original tasking requesting this office perform a spectrum analysis of the RF oven at Boeing-Vertol, Philadelphia, PA. Reference 1c was our report on that survey. It also established the need for another trip. Reference 1b advised Mr. Levin that equipment and personnel would be available during October. Reference 1a tasked this office to perform a second trip.

3. It was determined during the first trip that a true RF spectrum characterization of the RF oven had not been made because an actual working load was not available at that time. It was not known what changes in frequencies would occur during the heating and curing process of a fiberglass/epoxy composite load although it had been estimated that the frequency might vary between 75 MHz and 95 MHz.

4. During the second trip a Hewlett-Packard 141T Spectrum Analyzer was used with a vertically polarized dipole antenna mounted on a 6 foot tripod. Data were taken by photographing the screen of the spectrum

analyzer with a Polaroid camera. The fundamental frequency was determined by using the frequency counter supplied with the oven. This counter was checked against our own and proven to be accurate. Each time the oven was turned on (for 30 - 60 second durations), one or two pictures were taken of various portions of the spectrum.

5. It was found that the levels varied rather substantially during each short heating; therefore, the data (Table 1) are presented in 5 dB increments giving the median, range and increment for each harmonic. The highest measured level was -12 dBm at the 5th harmonic (456 MHz). This gives an ERP of 1300 milliwatts (31.1 dBm). With a building attenuation of 21 dB (estimated from Table 5, reference 1c), this would give an ERP of 10.74 mW (10.31 dBm) were the source a transmitter outside the building. At 3000 feet the received level would be -74.6 dBm. This level would be detectable, but with such low power it is doubtful it would cause much interference to other users because their power levels are significantly higher and the oven frequency is constantly changing. The highest measured level at the 4th harmonic (365 MHz) was -19 dBm. This gives an ERP of 165 milliwatt (22.2 dBm). With a building attenuation (see reference 1c, Table 5) of 24 dB, this appears as an ERP of .66 mW (-1.8 dBm) to receivers outside the building. At 3000 feet the received level would be -84.6 dBm. There are no ATC frequencies or other users within the range 362.0 - 368.3 MHz. The majority of all levels were below -30 dBm. The ERP for each worst case is given in Table 2.

6. The measured fundamental frequency ranged from 90.52 to 92.08 MHz. The range of the harmonics is given in Table 3. As the load heats, the frequency changes at a rapid rate, slowing down as the load reaches higher temperatures. The fundamental frequency generally tended to be lower as the load reached and surpassed 200 degrees F. The median frequency was in the range between 91.30 and 91.39 MHz, with an average of 91.26 MHz and a standard deviation of .4 MHz. Even though there are users in the 5th harmonic range (452.60 - 460.40 MHz), the continuously changing frequency would sweep through the user's receiver fast enough to cause him nothing but a short burst of interference. This would be similar in time durations to what would be experienced from automobile ignition noise or lightning.

7. It is not believed that any substantial interference will be experienced by any user in an area within 3000 feet of the oven location in building 307. As stated in paragraph 6 above, if any interference is experienced, it would be of very short duration (1 to 2 seconds or less) and should cause no hardship to the user.

8. A list of receiving facilities within a two mile radius of building 307 will be forwarded to Mr. MacLeish under separate cover.

CCC-EMEO-ECD
SUBJECT: Electromagnetic Radiation Survey, 20 KW 90 MHz RF Oven

9. Any further questions should be directed to Mr. Don Sambol, 602-538-5755/5303 (von 879).

FOR THE COMMANDER:

4 Incl
1-3. as
4 fwd sep

MILES A. MERKEL
Chief, Electromagnetics Engr Office

CF:
Mr. John E. MacLeish, P61-06 Boeing Vertol, P. O. Box 16858, Philadelphia, PA 19142

TABLE 1. MEASURED SIGNAL LEVELS

HARMONIC	MEASURED LEVEL RANGE (dBm)	MEDIAN INCREMENT GROUP (dBm)	NUMBER OF SAMPLES
Fundamental	-53 to -33	-46 to -50	13
2nd	-52 to -33	-41 to -45	17
3rd	-59 to -33	-46 to -50	31
4th	-44 to -19	-26 to -30	30
5th	-50 to -12	-26 to -30	27
6th	-53 to -31	-41 to -45	26
7th	-46 to -25	-36 to -40	28
8th	-68 to -49	-56 to -60	29
9th	-68 to -53	-56 to -60	28
10th	-66 to -45	-51 to -55	28
11th	-70 to -53	-61 to -65	26
12th	-68 to -63	-65.5	2
13th	-70 to -69	-69.5	2

TABLE 2. EFFECTIVE RADIATED POWER LEVELS

HARMONIC	WORST CASE - MEASURED (dBm)	ERP (mW)	ERP - TO INCLUDE BUILDING ATTENUATION (mW)
Fundamental	-33	.41	FM Broadcast Station
2nd	-33	1.66	No Bldg Attn Data
3rd	-33	3.70	.02
4th	-19	165.96	.68
5th	-12	1300.17	No Bldg Attn Data
6th	-31	23.63	2.42
7th	-25	127.94	11.40
8th	-49	.66	.004
9th	-53	.33	.0002
10th	-45	2.61	.11
11th	-53	.50	No Bldg Attn Data
12th	-63	.06	No Bldg Attn Data
13th	-69	.02	No Bldg Attn Data

TABLE 3. RANGE OF HARMONIC FREQUENCIES

HARMONIC	FREQUENCY (MHz)
Fundamental	90.52 - 92.08
2nd	181.04 - 184.16
3rd	271.56 - 276.24
4th	362.08 - 368.32
5th	452.60 - 460.40
6th	543.12 - 552.48
7th	633.64 - 644.56
8th	724.16 - 736.64
9th	814.68 - 828.72
10th	905.20 - 920.80
11th	995.72 - 1012.88
12th	1086.24 - 1104.96
13th	1176.76 - 1197.04

APPENDIX C

MATERIAL CERTIFICATION

FORM 9271-C-PWO

RP-1051

0 cc: with shipment
4 cc: J. T. Deasey
1 cc: Cy Yearwood
1 cc: Paul Milon

AFFIDAVIT

STATE OF MINNESOTA

ss.

COUNTY OF RAMSEY

The authorized representative of the Minnesota Mining and Manufacturing Company, St. Paul, Minnesota, whose signature is given below, being first duly sworn, does depose and say that the "SCOTCHPLY" Brand Reinforced Plastics Material described below, complies with mutually agreed Specifications and Purchase Order Requirements. The Quality Control System complies with all essential principles of Specifications MIL-I-45208A and MIL-Q-9858. Test reports and traceability records will be kept on file, available for review by the buyer. Copies of 3M Lot Acceptance Data Reports and the Shipment Check List, as may be required, are attached to this Affidavit.

Customer Name and Plant Location: Boeing Co., Vertol Div., Eddystone, PA

Customer Purchase Order Number: TT 807185

3M Company Shipment Invoice Number: RP 47932

Applicable Customer Specification: BMS-8-196A, Class A, Type I-1

3M Company Product Identification: Type SP-250-E-33, Unidirectional

3M Company Product Mfg. Code: W 456, Lot 7, Jumbo 50

Shipment Summary:

42 Rolls, 6½" X 72 Yards. 1-Ply Uni.

3M Lot Test Data is Attached.

IR & GPC curves are identified as S05707, Lot 83, Jumbo 50

Further this Affiant sayeth not.

Title: Supervisor Quality Control

Subscribed and sworn to before me this 26th day of March, 1979 A.D.

3M COMPANY - QUALITY CONTROL LOT ACCEPTANCE DATA REPORT

APPLICABLE SPECIFICATION: BOEING-VERTOL BMS-8-196A CLASS A TYPE 1

3M PRODUCT TYPE - SP-250-E-33

3M MFG. CODE: W-456 LOT 7 JUMBO NUMBER 50 ORIENTATION: UNIDIRECTIONAL

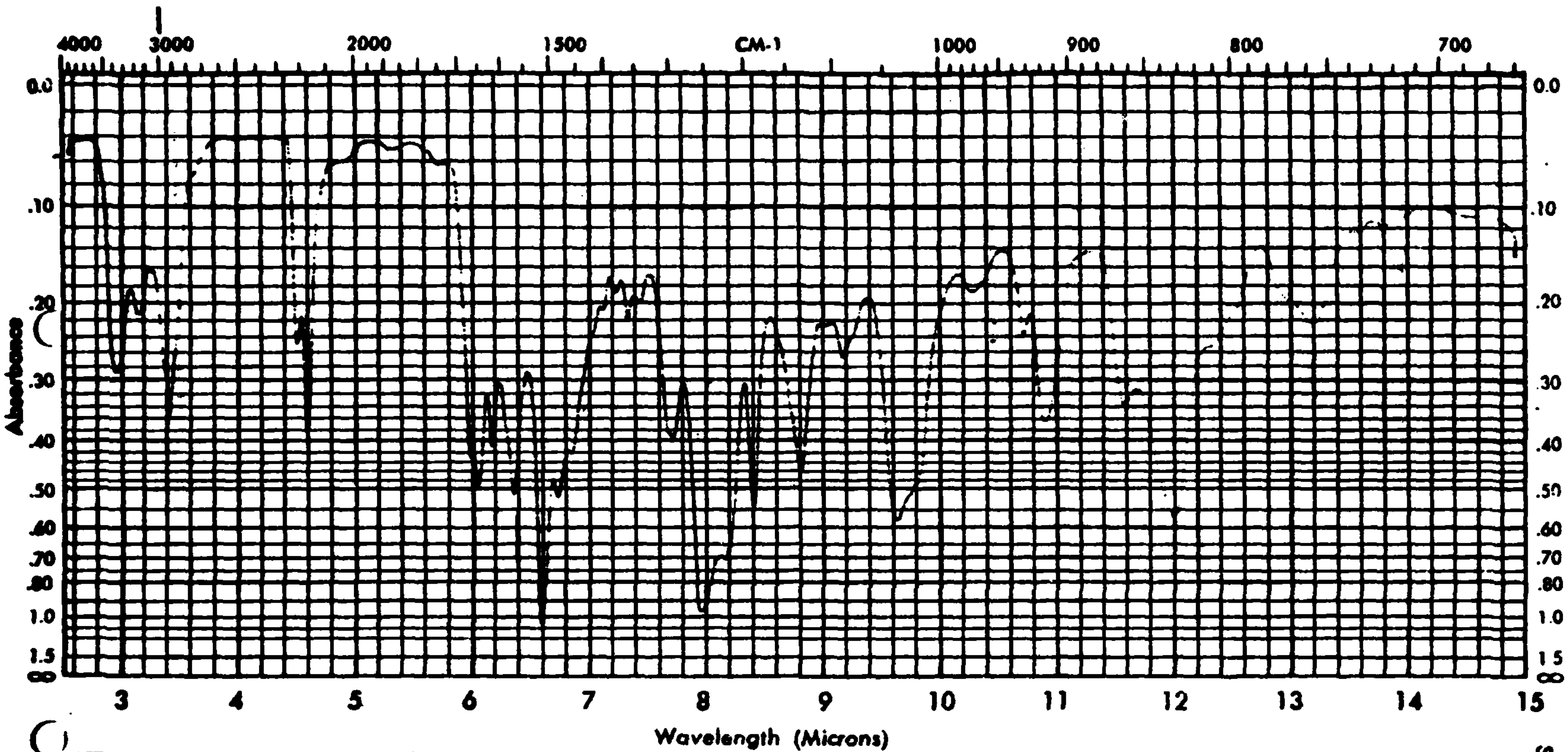
PREPREG PROPERTIES:			REQUIREMENTS	AVERAGE VALUE	TEST # 1	TEST # 2	TEST # 3
Volatile Content, %w			0.6 (0.8)	0.4	0.4	0.4	0.4
Resin Content, %w			30-36	30	29.4	30.8	30.4
Glass Weight, Grams/Sq. Ft.			25.2-27.6	26.0	25.74	26.17	26.15
Total Weight, Grams/Sq. Ft.			36.25-42.55	37.5	36.64	38.05	37.77
GelTime, Minutes			33 Minimum	40	39.2	40.8	39.0
Resin Flow, %w			9-17 (8-18)	11	11.0	10.4	
LAMINATE PHYSICAL PROPERTIES:(12 PLY)							
Void Content, %v			3.5	0.0	0.0	0.0	0.0
Fiber Content, %v			Report	56.7	56.8	56.7	56.6
Composite Density, Lb./Cu. In.			Report	0.071	0.071	0.071	0.071
Layer Thickness, Inches			.0075-.0095	0.0078	0.0077	0.0080	
LAMINATE PHYSICAL PROPERTIES: (5 PLY)							
Void Content, %v			3.5	0.0	0.0	0.0	0.0
Fiber Content, %v			Report	57.9	57.7	57.9	58.0
Cured Resin Content, %v			Report	27.4	27.6	27.3	27.2
Composite Density, Lb./ Cu. In.			Report	0.071	0.071	0.071	0.071
Layer Thickness, Inches			.0075-.0095	0.0078	0.0076	0.0080	
MECHANICAL PROPERTIES:							
0^o Beam Shear	@ RT	KSI	10.0 (9.5)	13.5	13.47	13.54	13.50
0^o Flex Strength	@ RT	KSI	160 (140)	209	204.3	207.3	216.2
0^o Flex Modulus	@ RT	MSI	5.3 (4.8)	6.5	6.59	6.29	6.56
0^o Tension Strength	@ RT	KSI	SEE FIGURE SIX	172	174.4	169.1	172.8
0^o Tension Modulus	@ RT	MSI	SEE FIGURE SIX	6.6	6.77	6.61	6.53

( ) INDIVIDUAL VALUES

DATE: 3-29-79

TABULATED BY: T. E. Sklenar

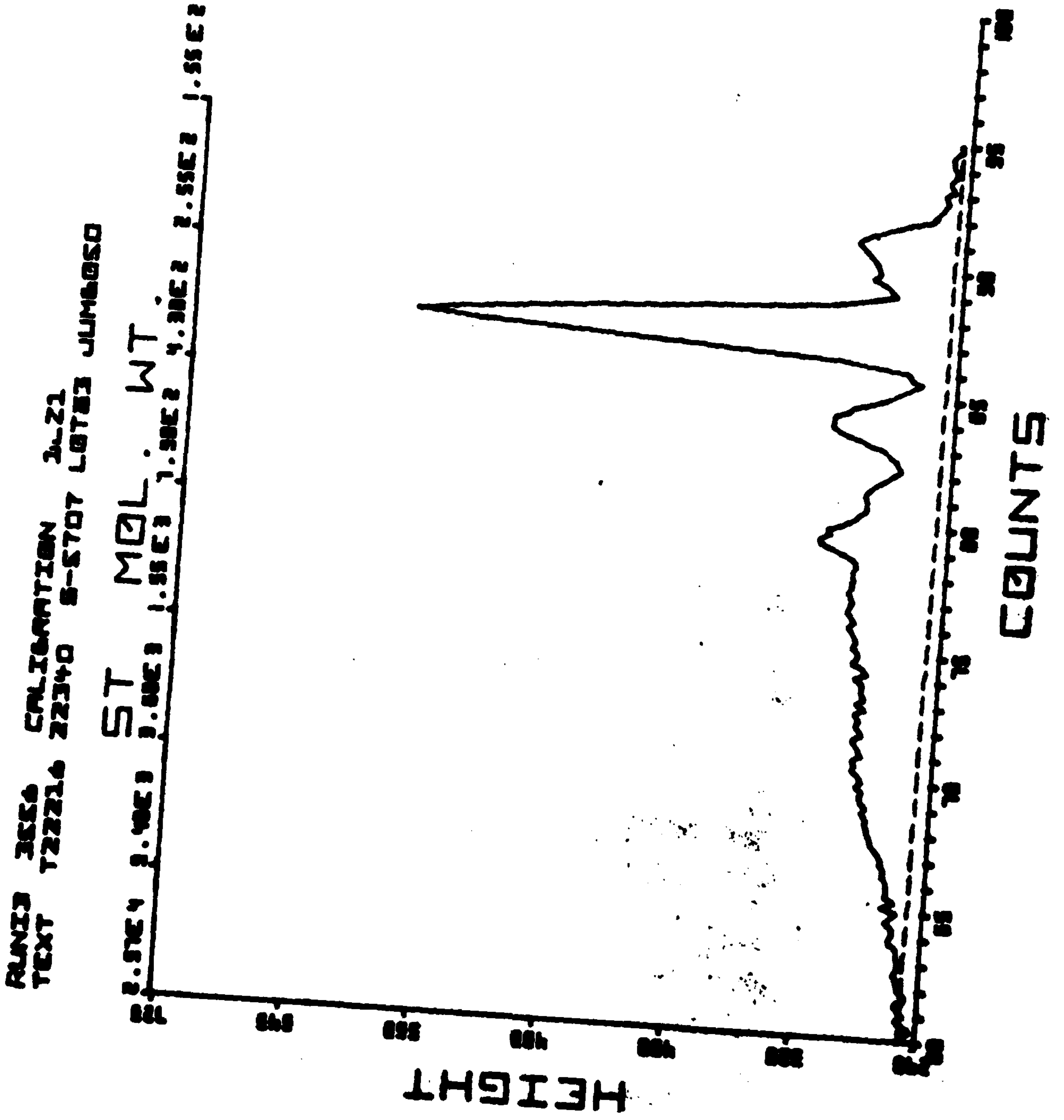
SUPERVISOR QUALITY CONTROL



Spectrum No. ____

Sample ____

Results ____		Req. No. 9427 Date 12/7/78	Minnesota Mining & Mfg. Co. Tape Research
	S ____	Requestor D. J. Nitzki	
	Cl ____		Spectrum No. 65586
	N ____	Lab. No. ____	Sample # 50
	P ____	Solid Tackey	SD 5727
	ΦOH ____	Liquid ____	Genuka 50
	C ____	Gas ____	Lot - 83
	H ____		Source ____
		Operator RLS	Mach. No.


ST MOL. WT.
HEIGHT
COUNTS

APPENDIX D

QUALIFICATION ASSURANCE REPORT

QUALITY ASSURANCE M&P LABORATORY
MISCELLANEOUS TEST DATA

TEST	RESULTS 1	2	3	4	5
VOLATILES	0.17%	0.19%	Average =	0.18%	
SOLIDS					
CHECK ONE ☒ WET RESIN ☐ DRY RESIN ☐ CURED RESIN	30.0%	30.6%	Average =	30.3%	
CHECK ONE ☐ WET RESIN ☐ DRY RESIN ☐ CURED RESIN					
FLOW	10.8%	9.4%	Average =	10.1%	
GEL TIME	Satisfactory 33 minutes at 200°F				
APPLICATION TIME	(Approximately 50 minutes)				
SHORE A HARDNESS					
POROSITY					
GLASS WT	1-	2-	3-	4-	5-
	6- 26.28 Gr/ft²		8-	9-	10-
TOTAL WT	1-	2-	3-	4-	5-
	6- 37.79 Gr/ft²		8-	9-	10-
WEIGHT					
THICKNESS	0.0095 inch				
BARCOL HARDNESS	1-	2-	3-	4-	5-
	6-	7-	8-	9-	10-
ORIENTATION OF PLIES					
FOAMING HEIGHT					
HEIGHT BEFORE					
HEIGHT AFTER					
RESULT					
FOAMED APPEARANCE					
FLEXURAL STRENGTH - SPAN:					
WIDTH					
THICKNESS					
LOAD					
PSI					

WEIGHT		BEFORE	AFTER
VOLATILES	1	2.3453	2.3412
	2	2.3789	2.3744
	3		
SOLIDS	1		
	2		
CHECK ONE (WET RESIN)	1	2.3412	1.6380
	2	2.3744	1.6465
	3		
CHECK ONE	1		
	2		
	3		
FLOW	1	9.4739	8.4509
	2	9.5944	8.6921

MATERIEL IDENTIFICATION:

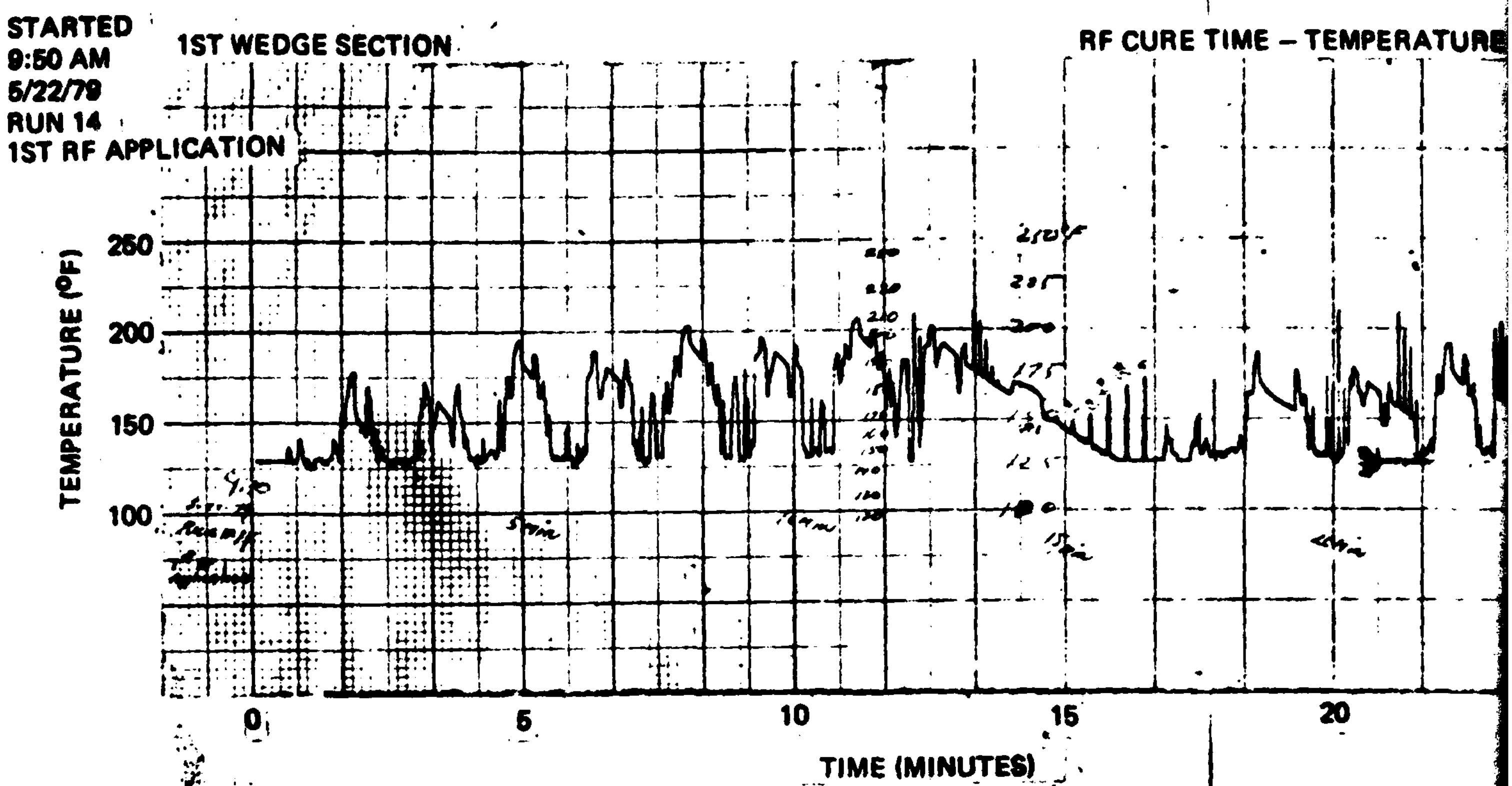
Prepreg
Properties,
Table I.

SP-250 456 E Fiber
BMS 8-196A

LOG NO.	DATE	SIGNATURE (ANALYST)
798 2553	7/30/79	[signature]

FORM 82600 (8/73)

APPENDIX E
TIME TEMPERATURE PROFILE FOR RF CURE PANELS



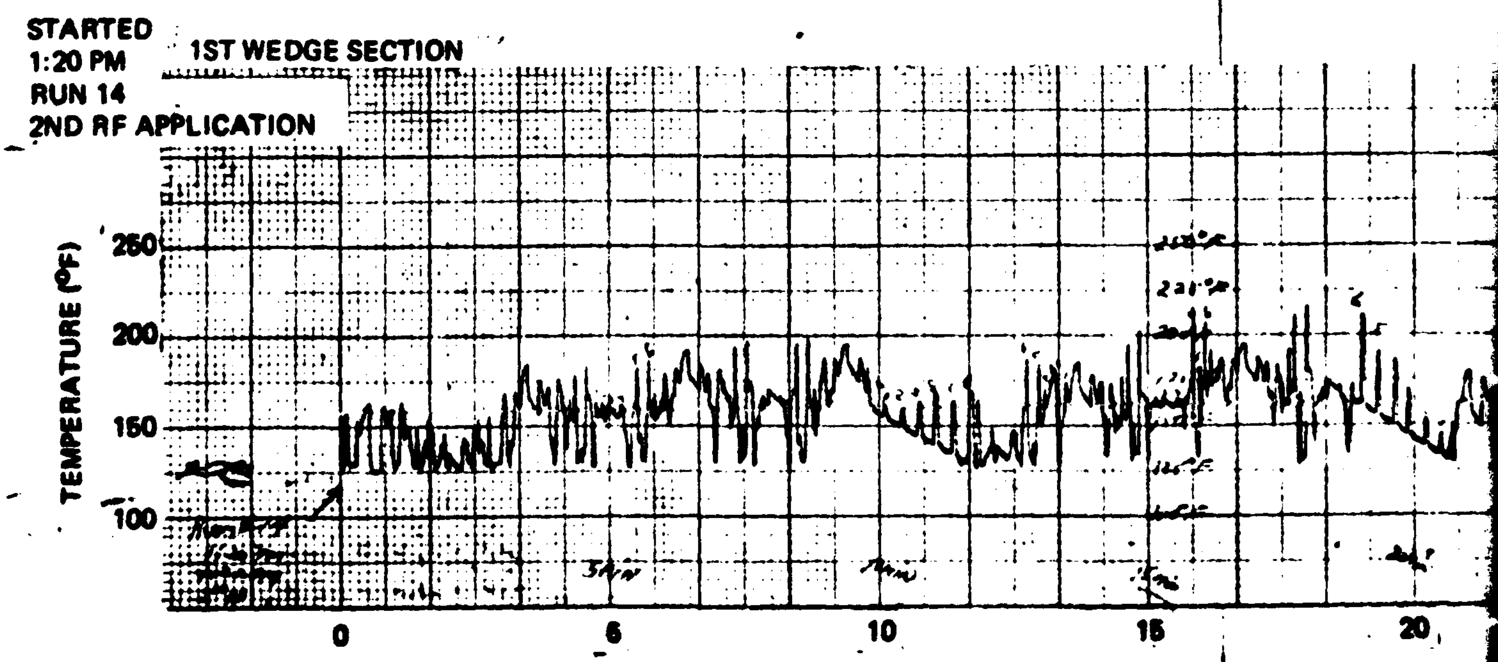
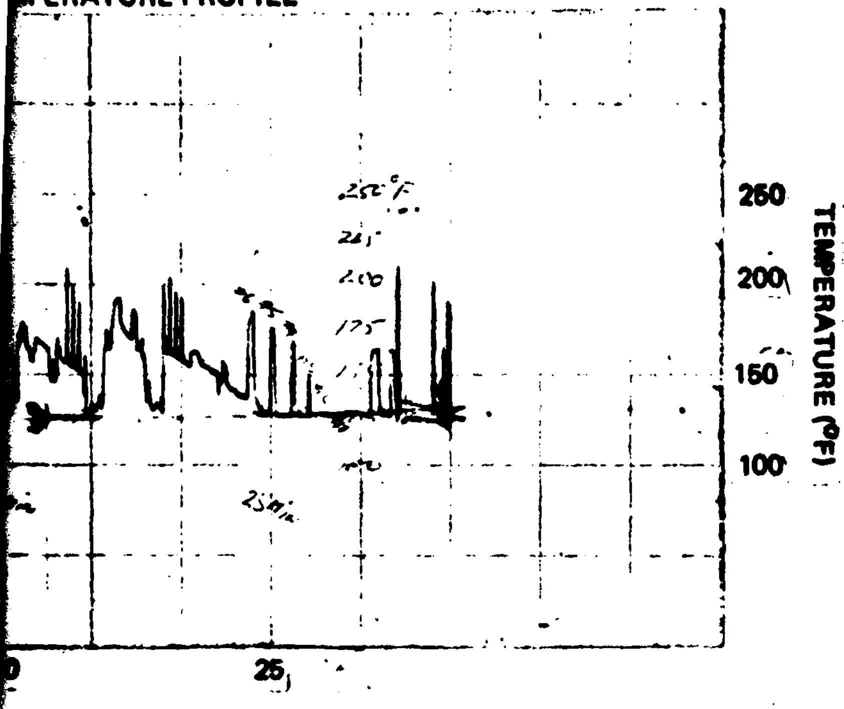
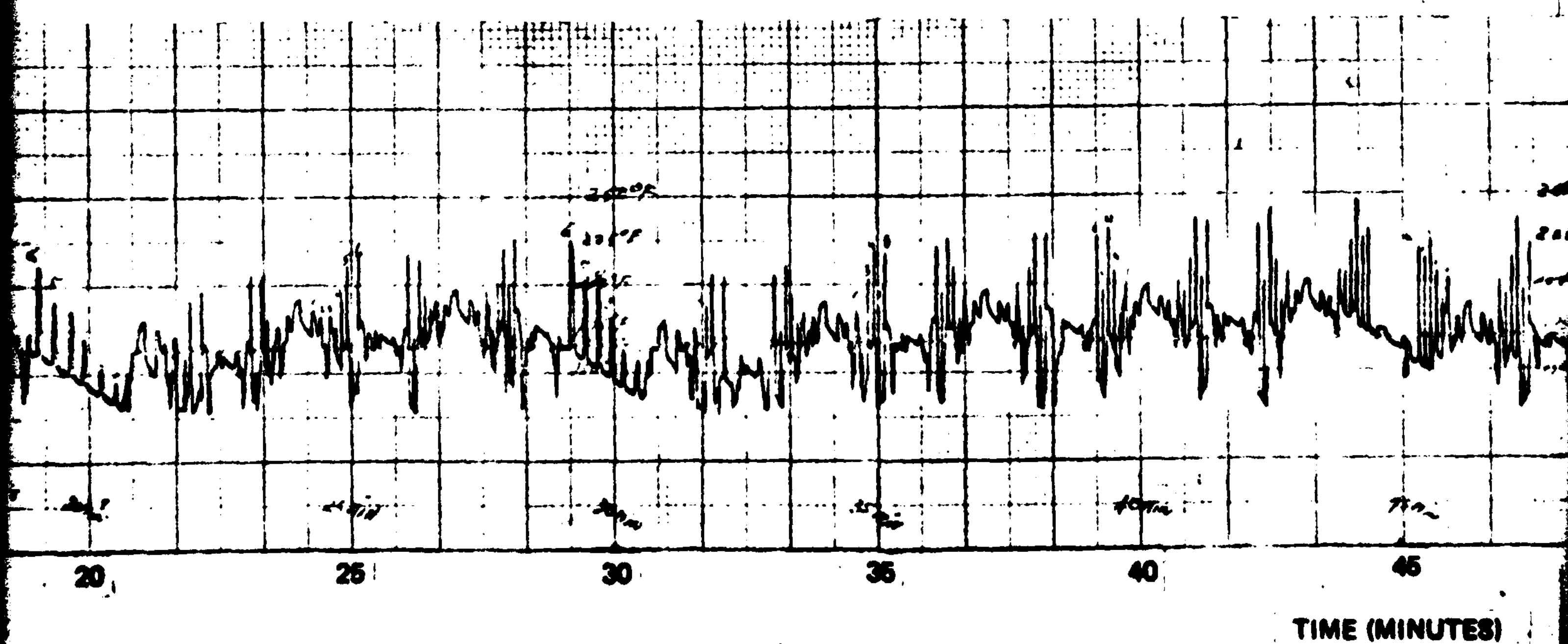
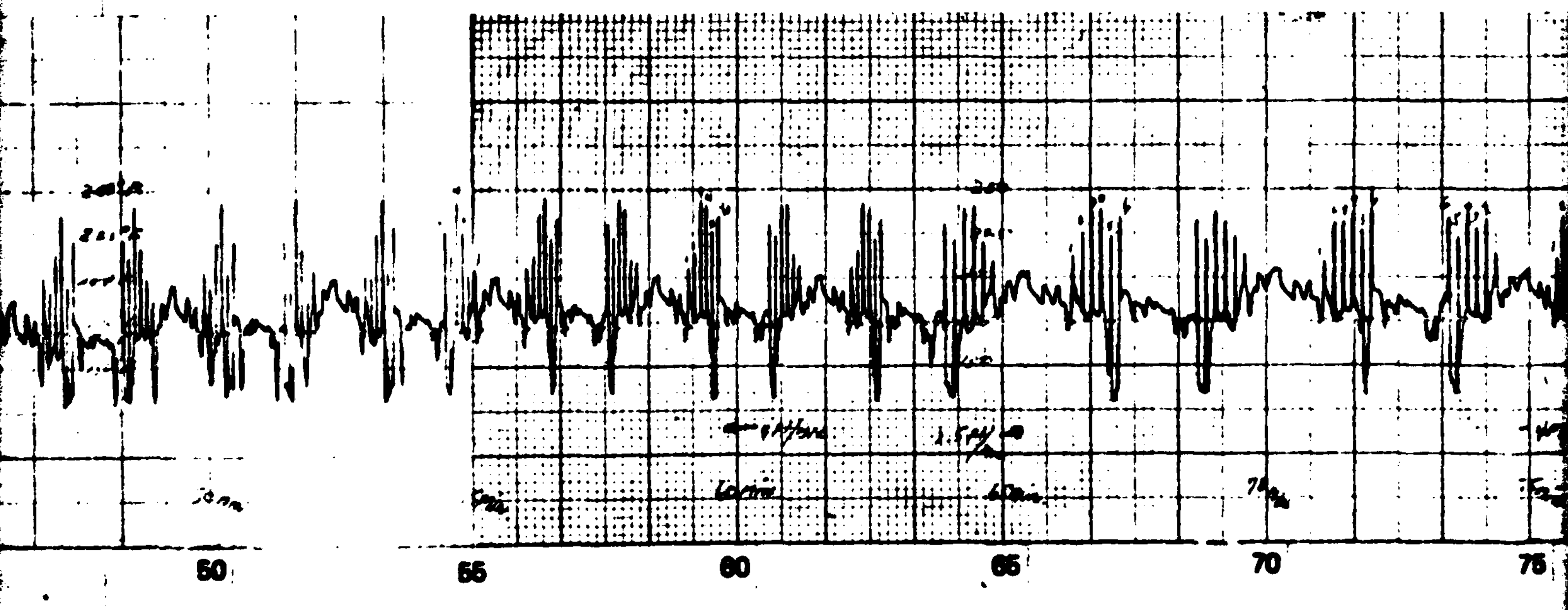


Figure E–1. Temperature Printout for 1st Wedge Section (Run Number 14)

PERATURE PROFILE

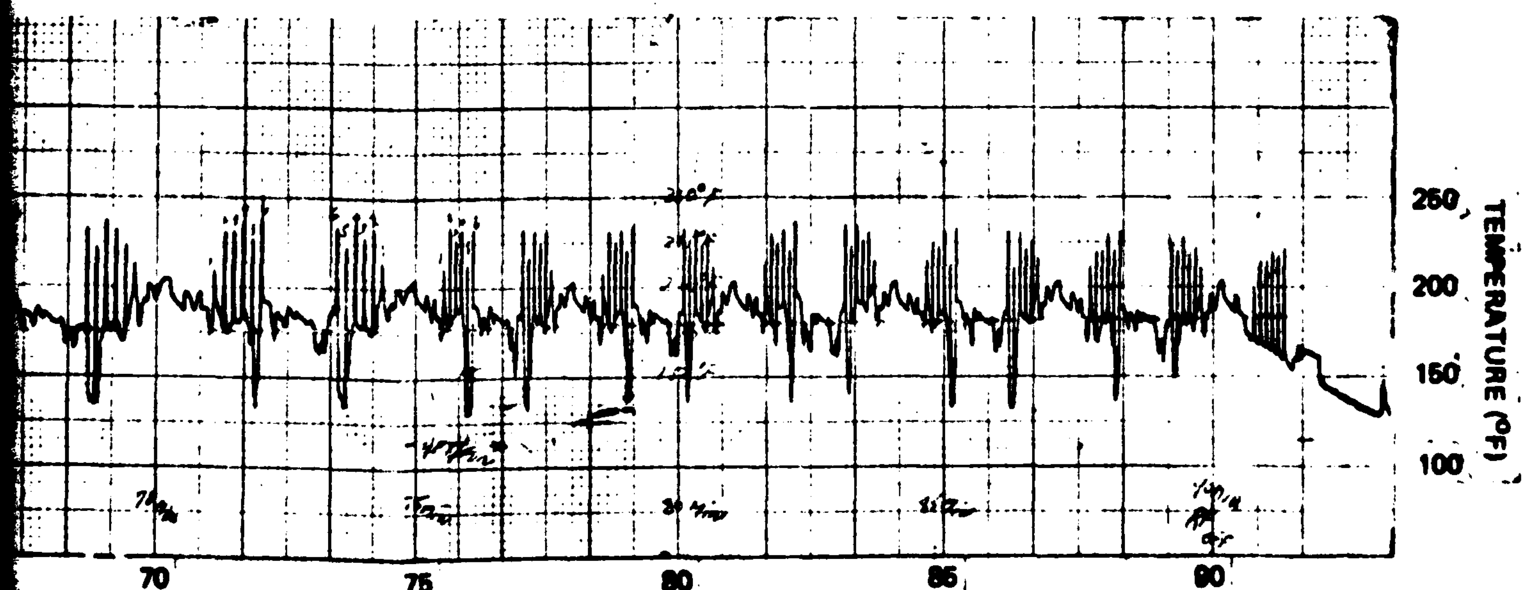




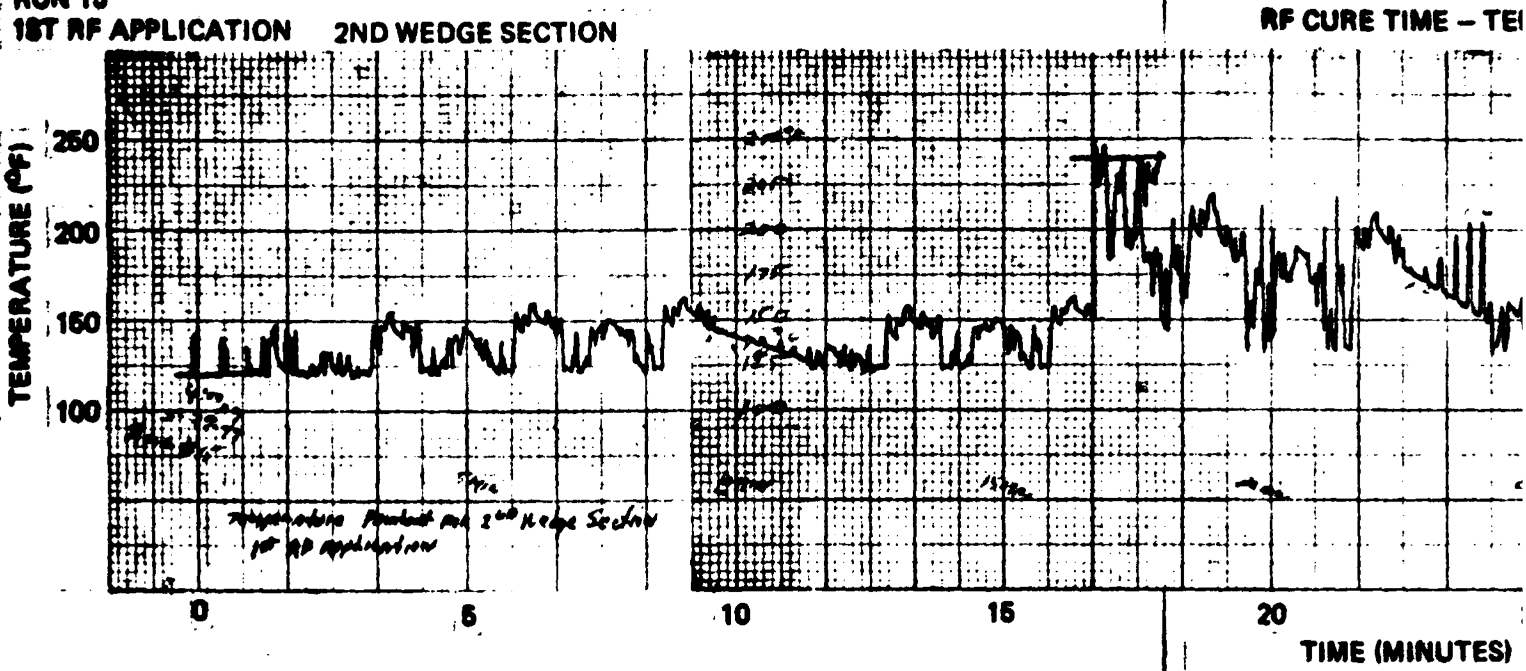


3

H


250
200
150
100
TEMPERATURE (°F)
70
75
80
85
90

STARTED
9:00 AM
5/29/79
RUN 15
1ST RF APPLICATION 2ND WEDGE SECTION



STARTED
1:20 PM
5/29/79
RUN 15
2ND RF APPLICATION 2ND WEDGE SECTION

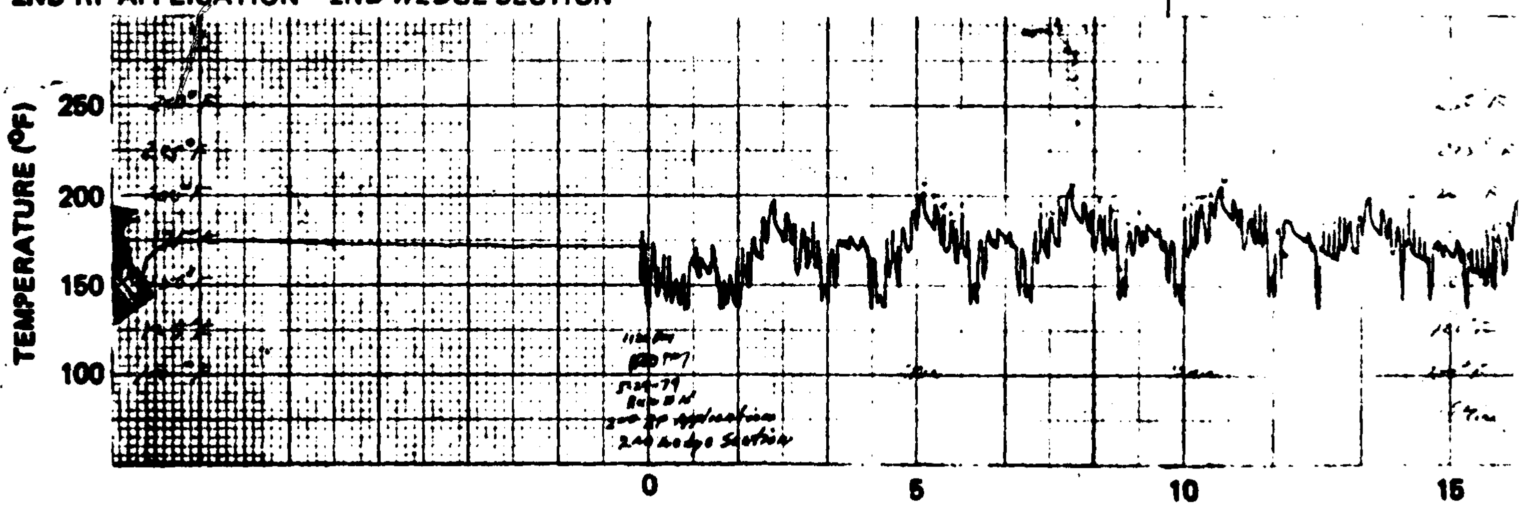
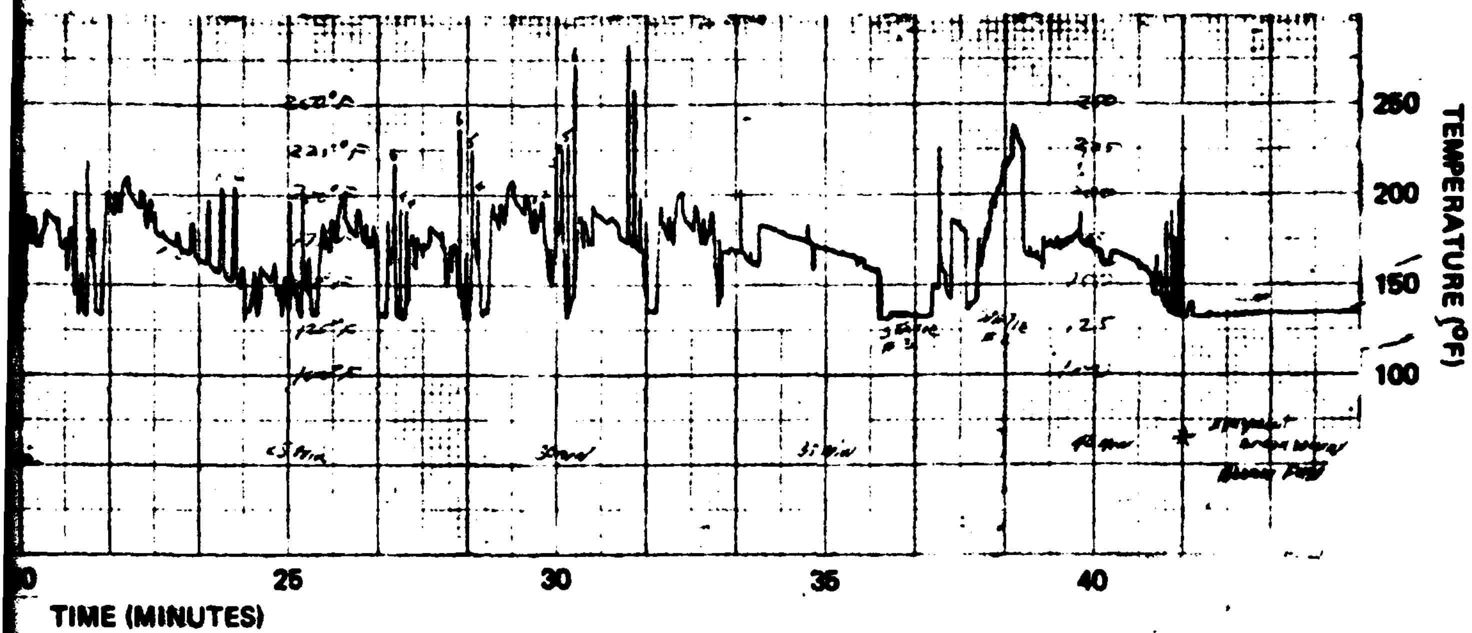
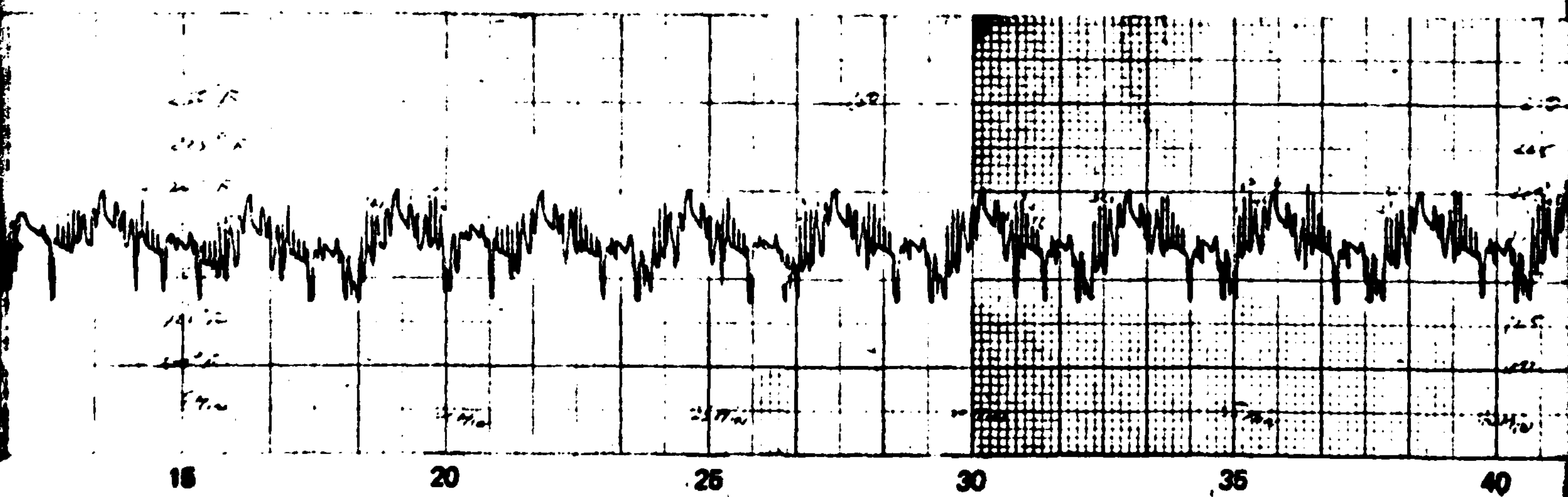
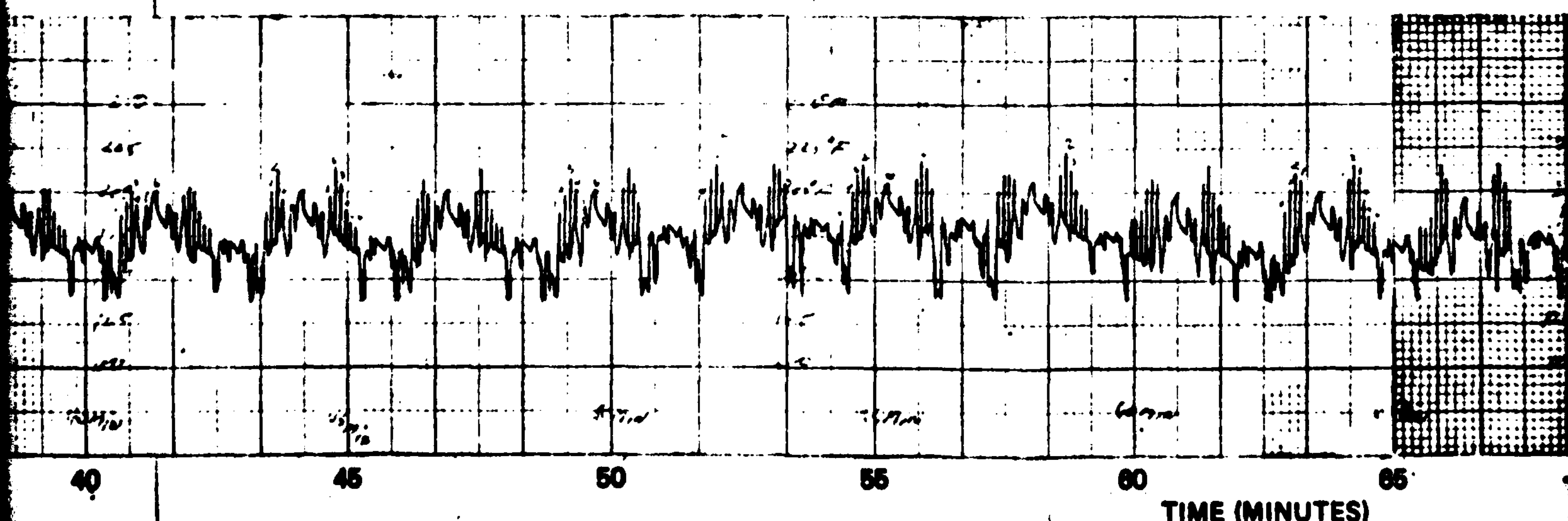


Figure E–2. Temperature Printout for 2nd Wedge Section (Run Number 15)

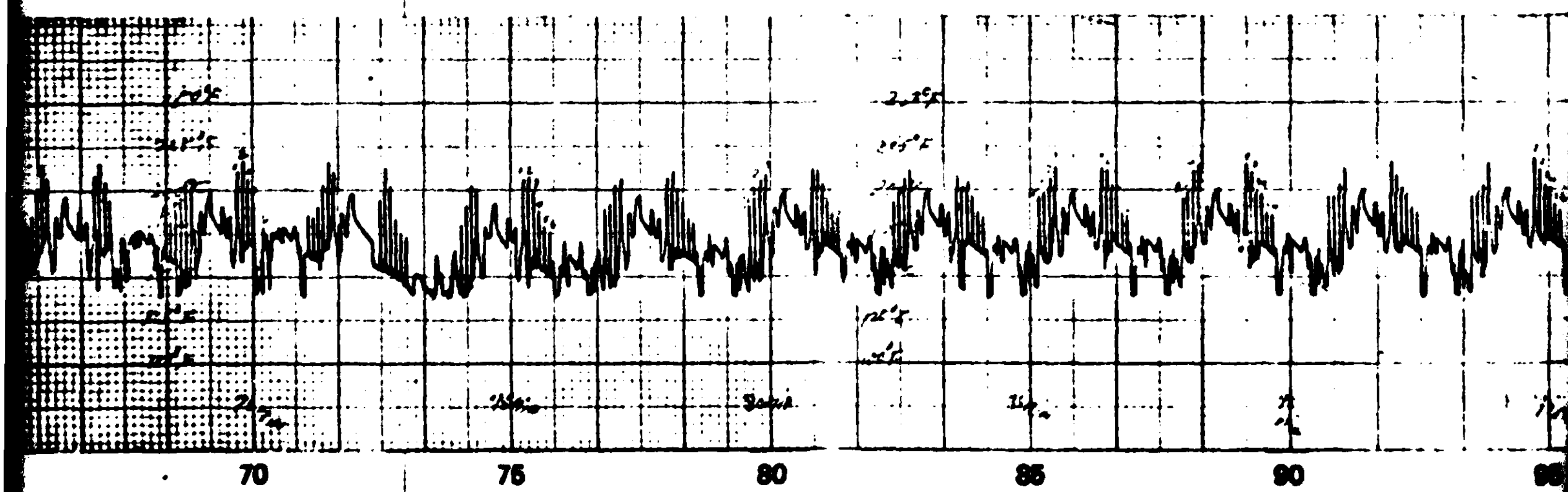
CURE TIME – TEMPERATURE PROFILE

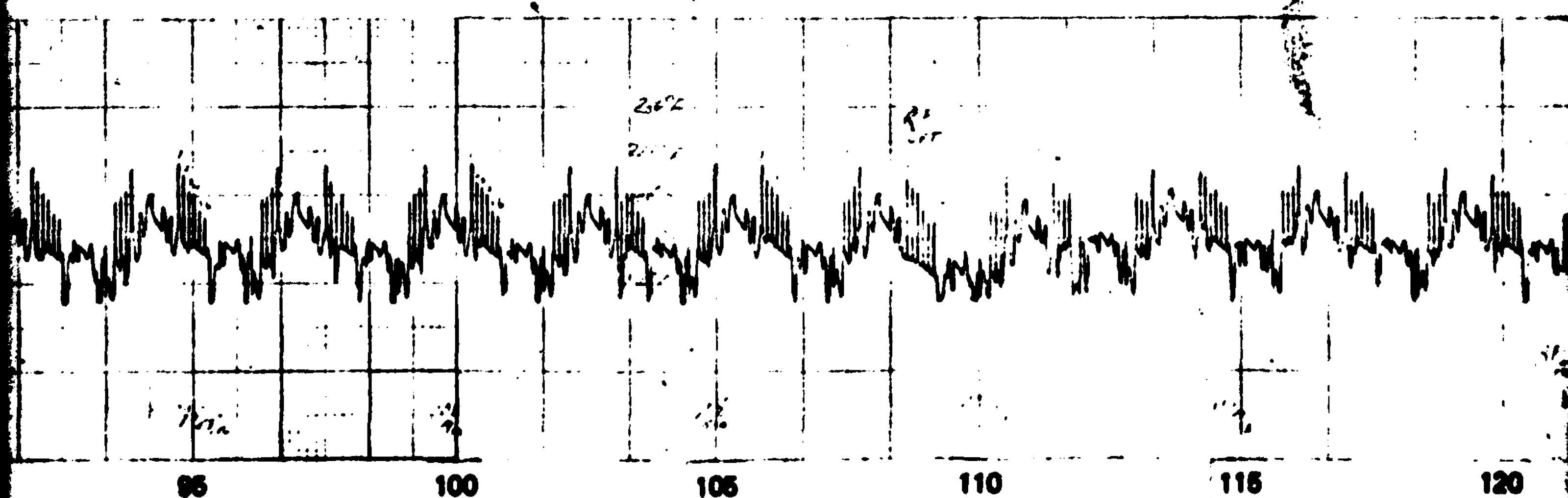




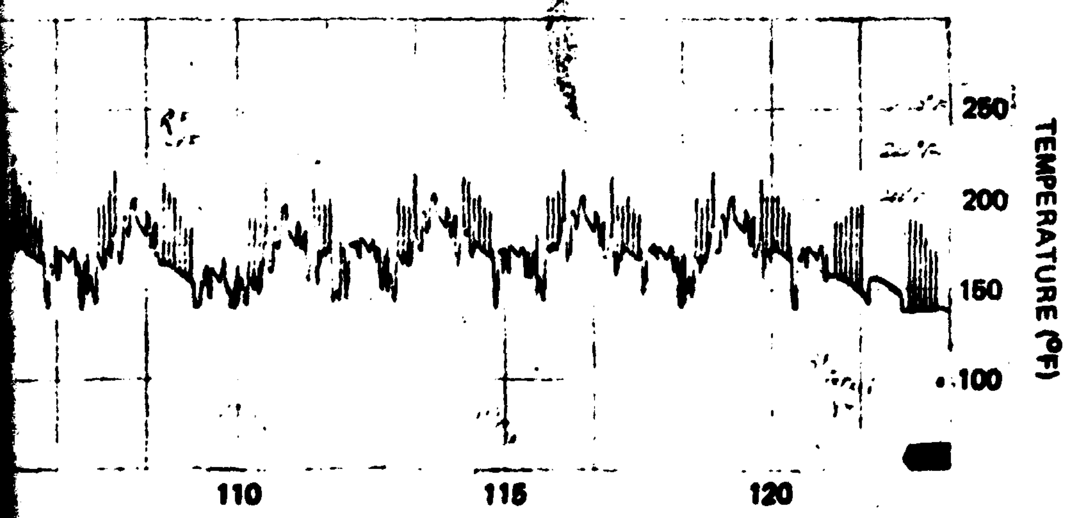


3


70
75
80
85
90
95



6


TEMPERATURE (°F)
250
200
150
100
110
115
120

STARTED
9:25 AM
6/8/79
RUN 16 3RD WEDGE SECTION

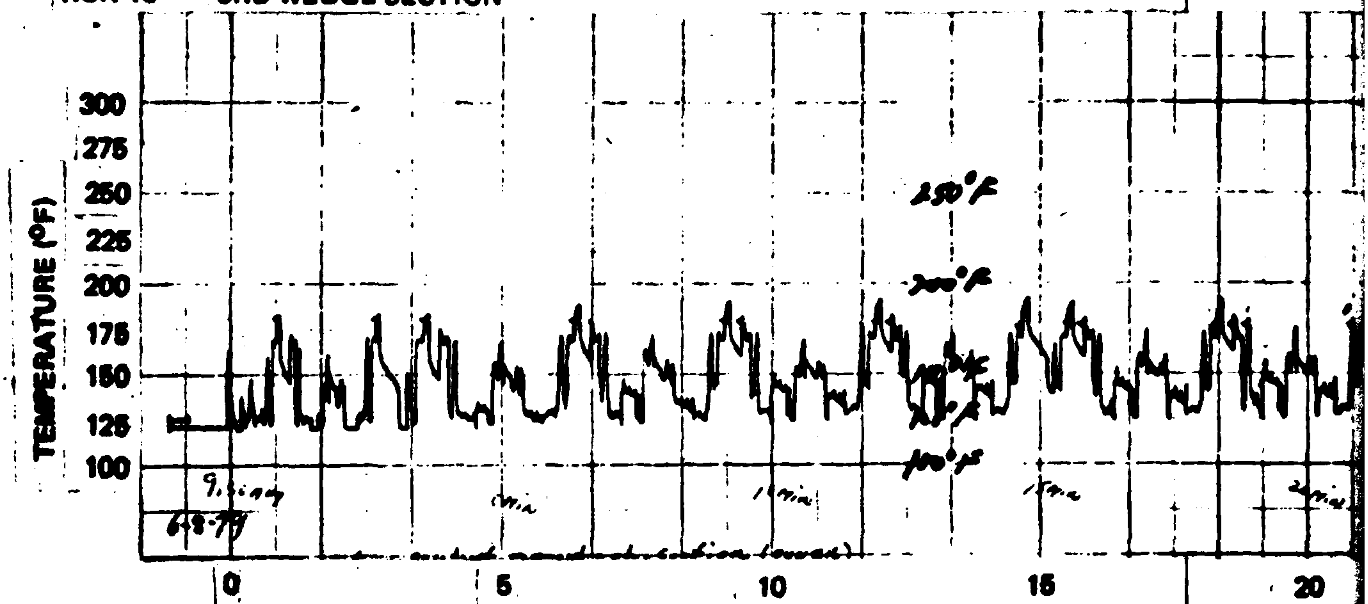


Figure E–3. Temperature Printout for 3rd Wedge Section (Run Number 16)

STARTED
9:25 AM
6/29/79
RUN 17 1ST CONSTANT THICKNESS SECTION

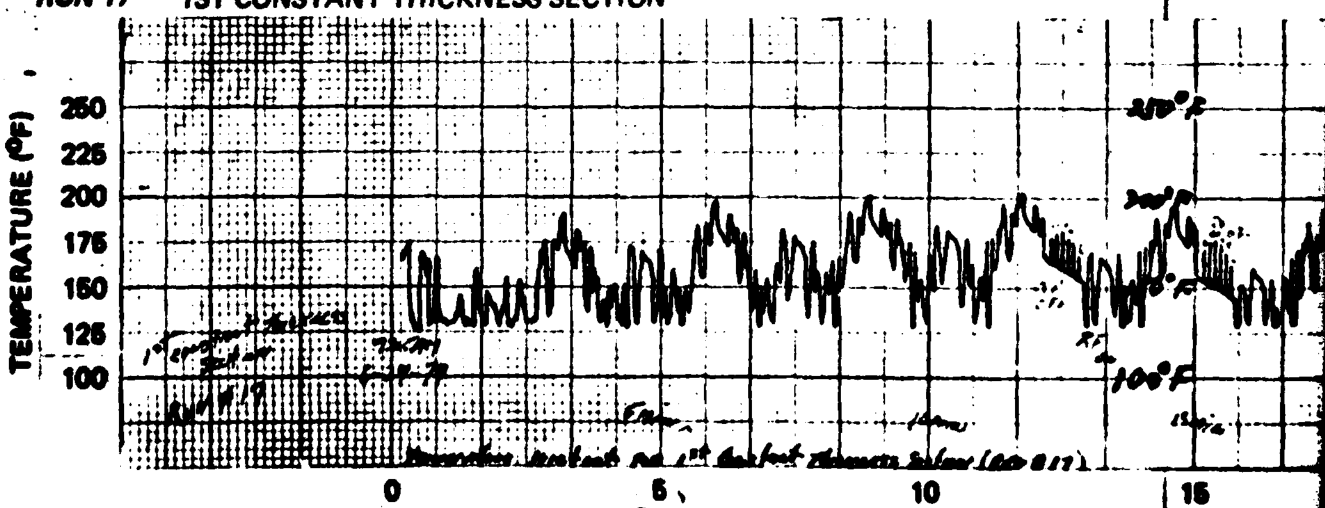
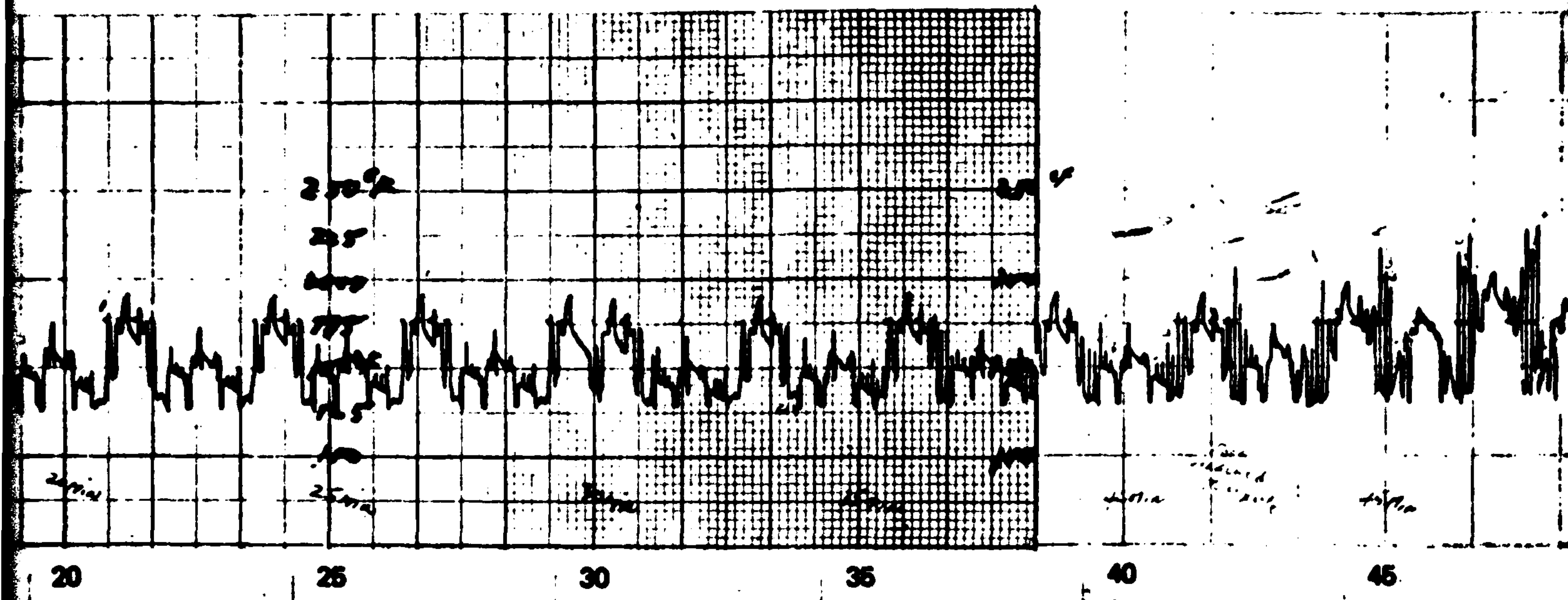
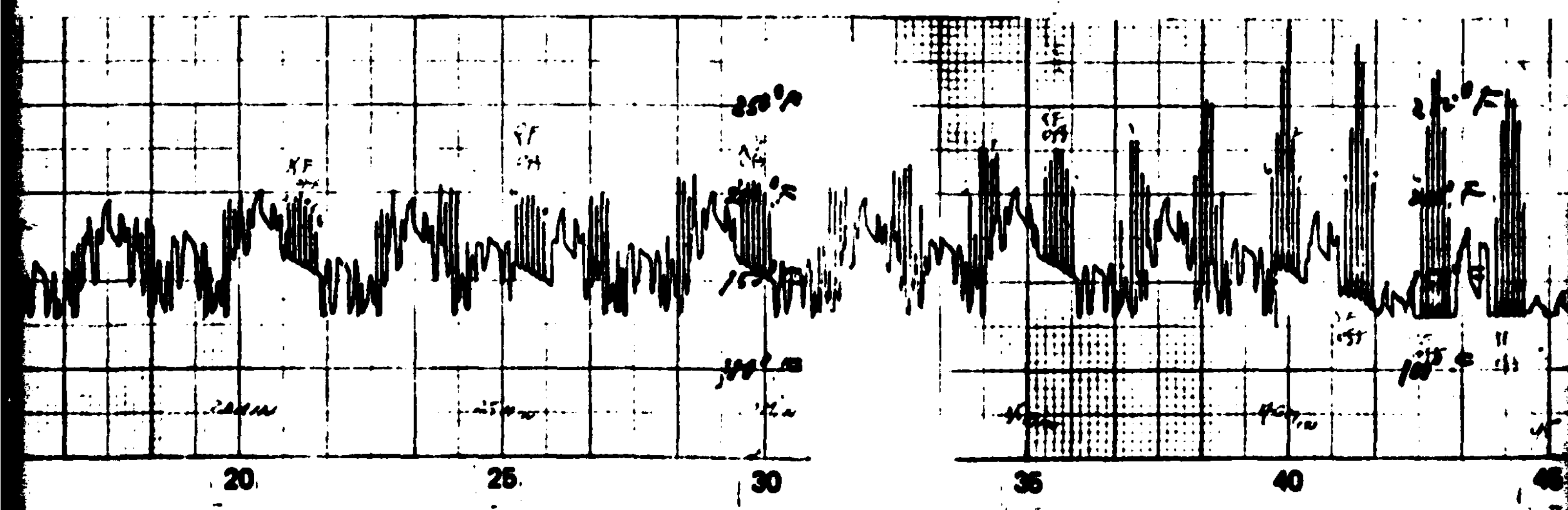
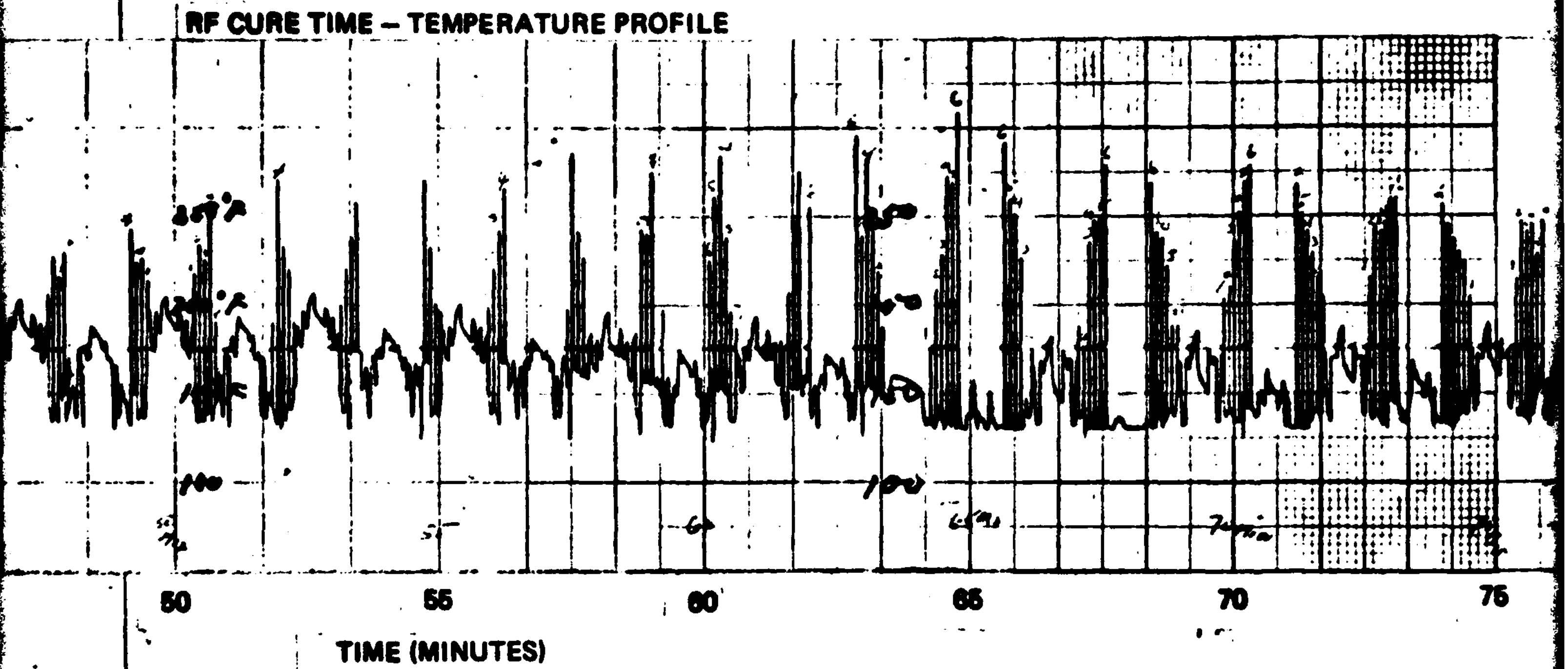
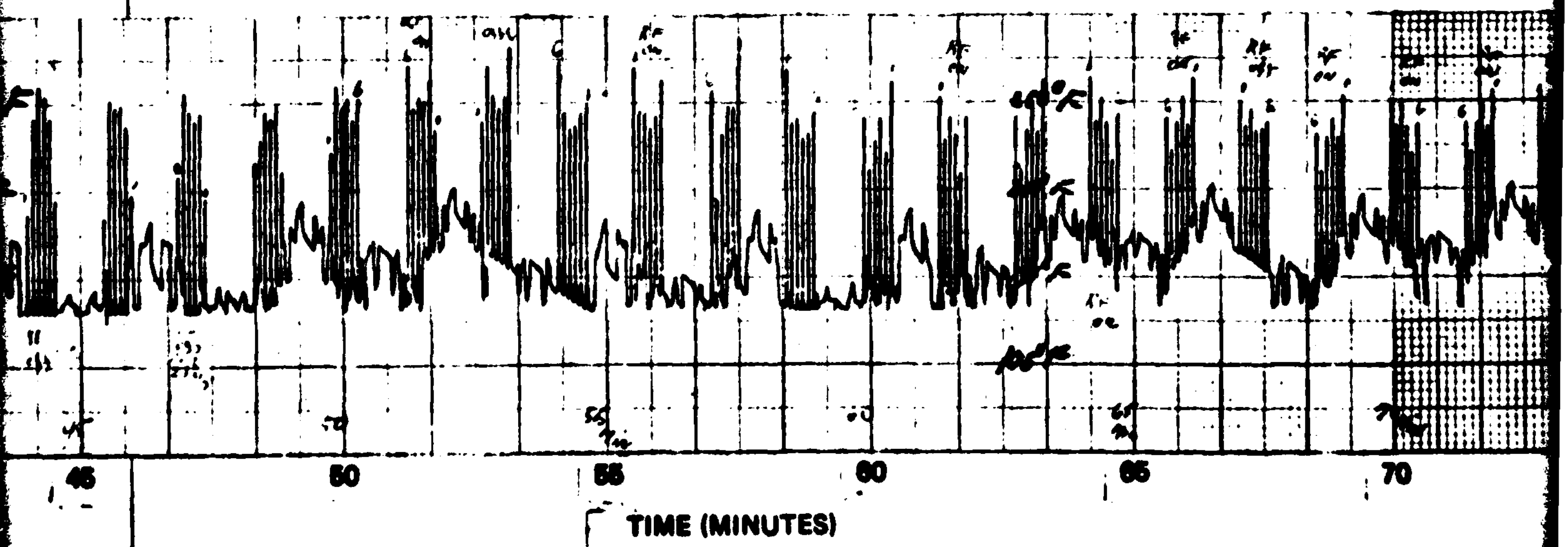


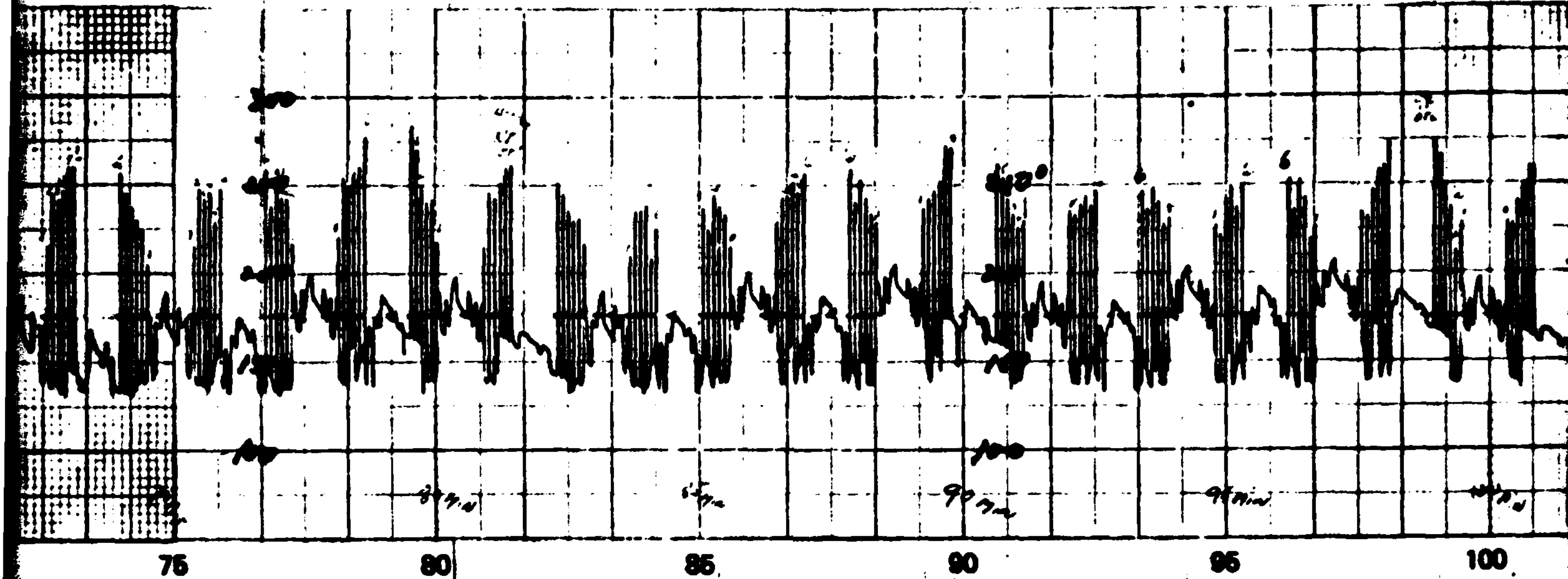
Figure E–4. Temperature Printout for 1st Constant Thickness Section (Run Number 17)

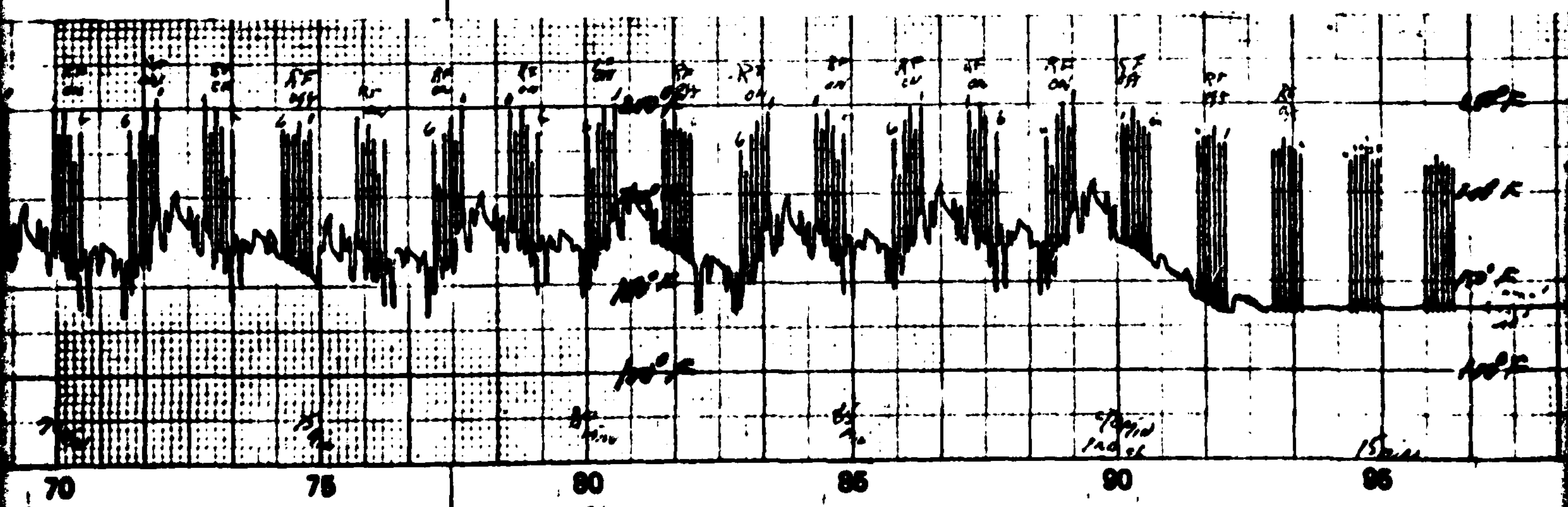

20
25
30
35
40
45

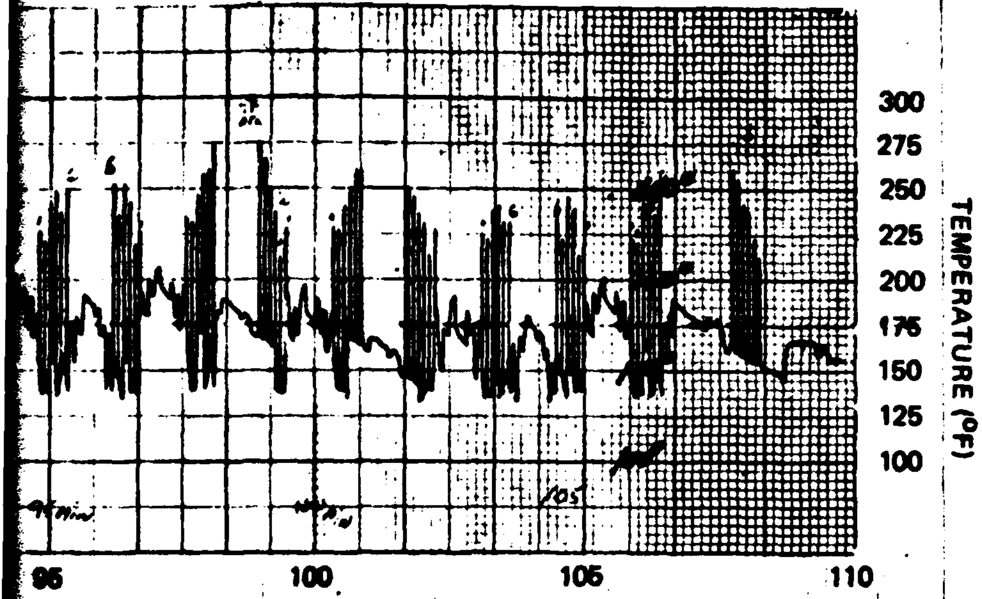

20
25
30
35
40

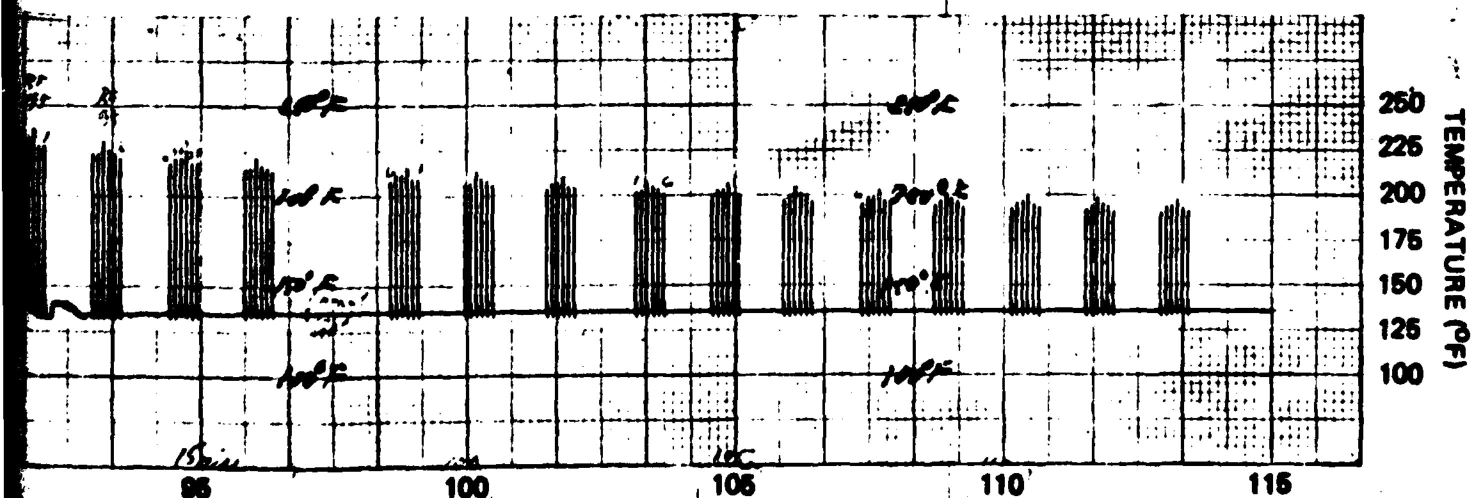

RF CURE TIME – TEMPERATURE PROFILE
50
55
60
65
70
75
TIME (MINUTES)


45
50
55
60
65
70
TIME (MINUTES)


75
80
85
90
95
100


70
75
80
85
90
95


300
275
250
225
200
175
150
125
100
TEMPERATURE (°F)
95
100
105
110


250
225
200
175
150
125
100
TEMPERATURE (°F)
95
100
105
110
115

4)

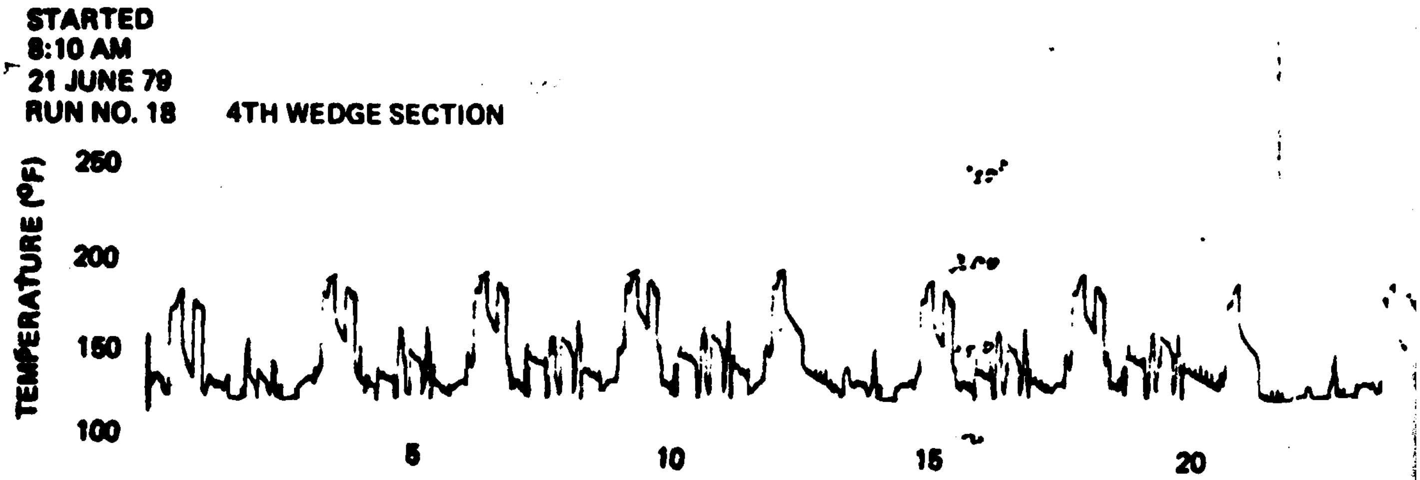


Figure E–5. Temperature Printout for 4th Wedge Section (Run Number 18)

5

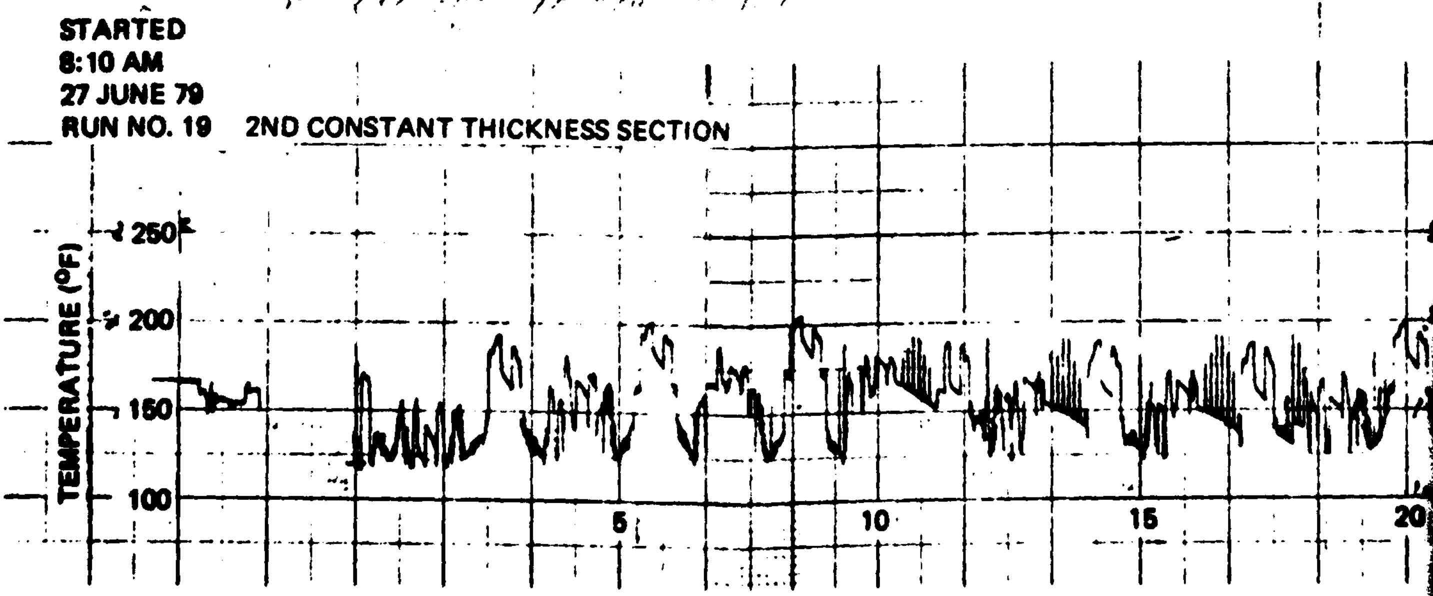
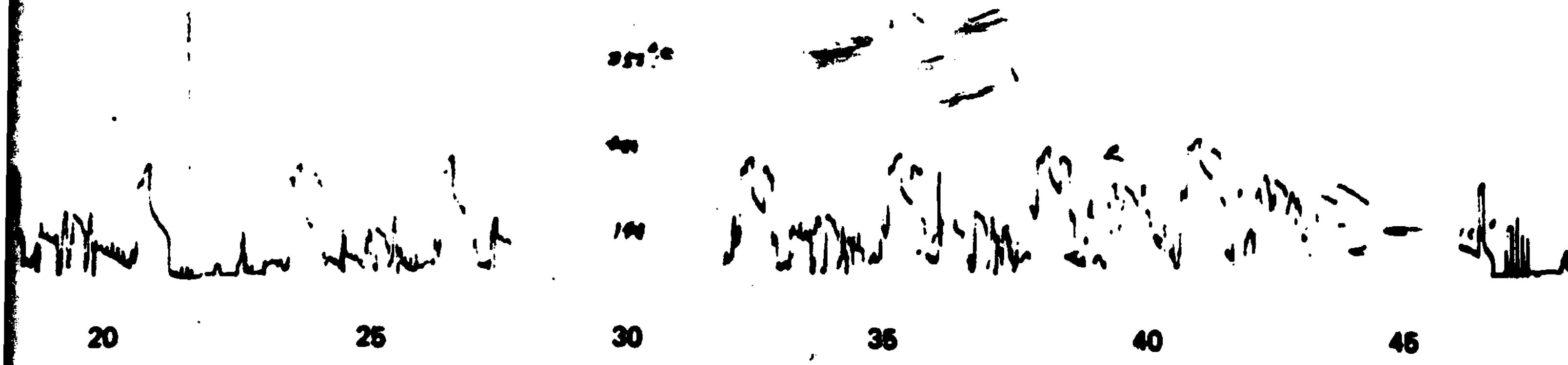
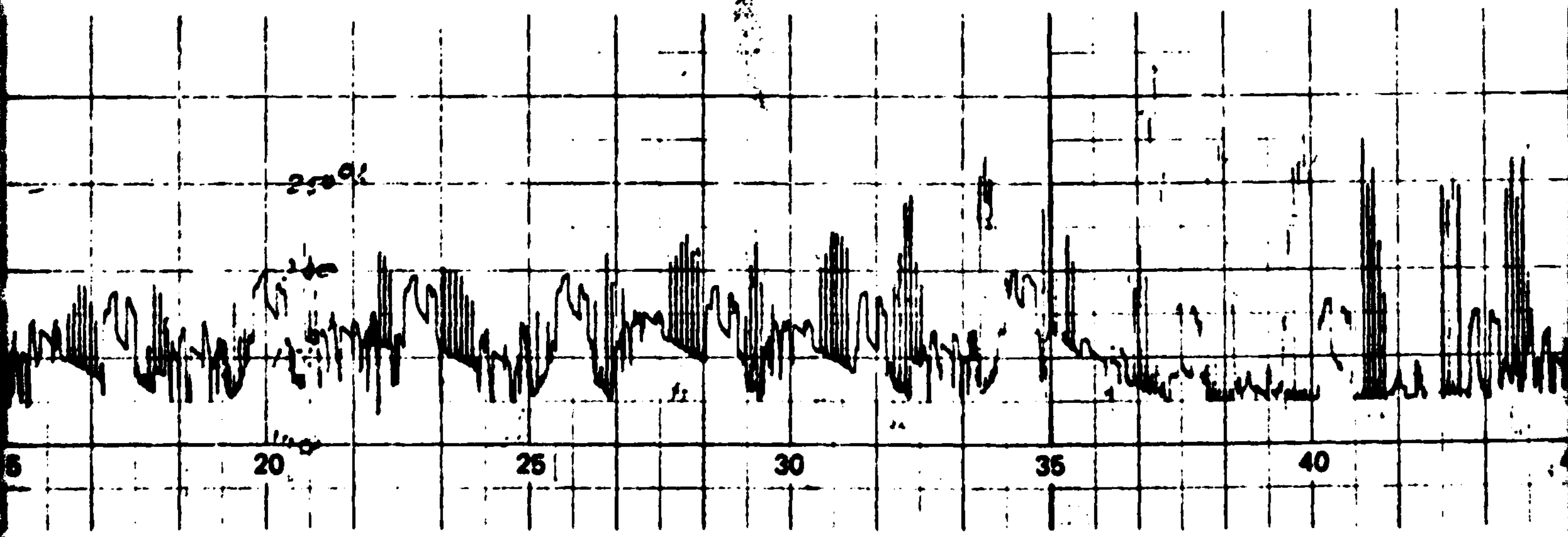
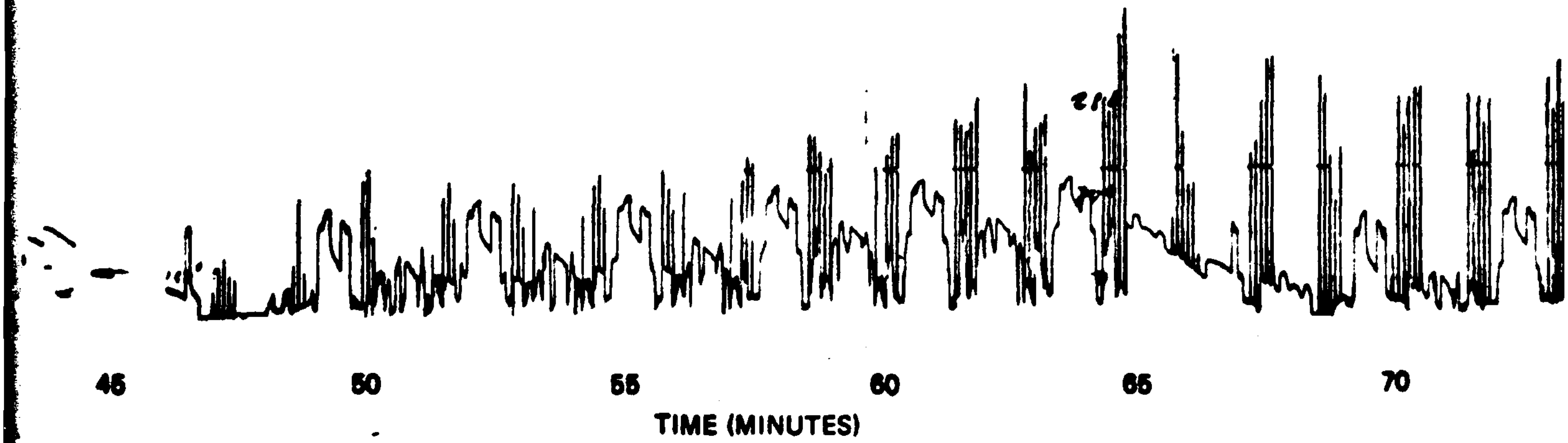


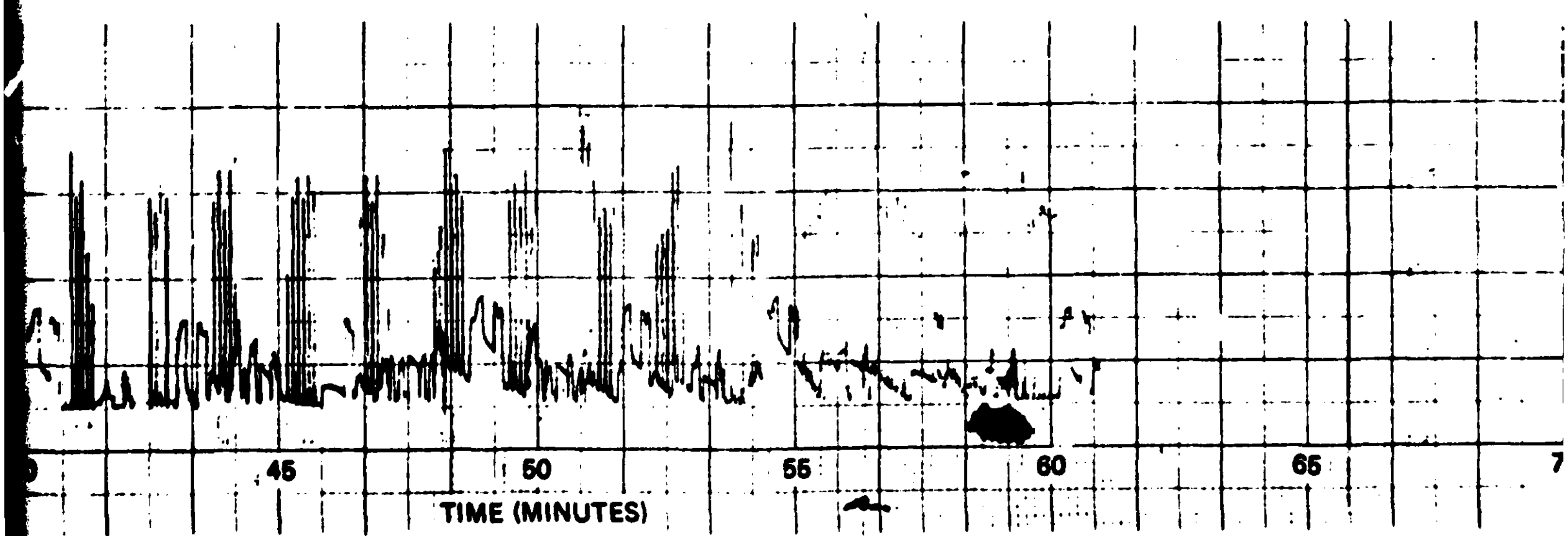
Figure E–6. Temperature Printout for 2nd Constant Thickness Section (Run Number 19)

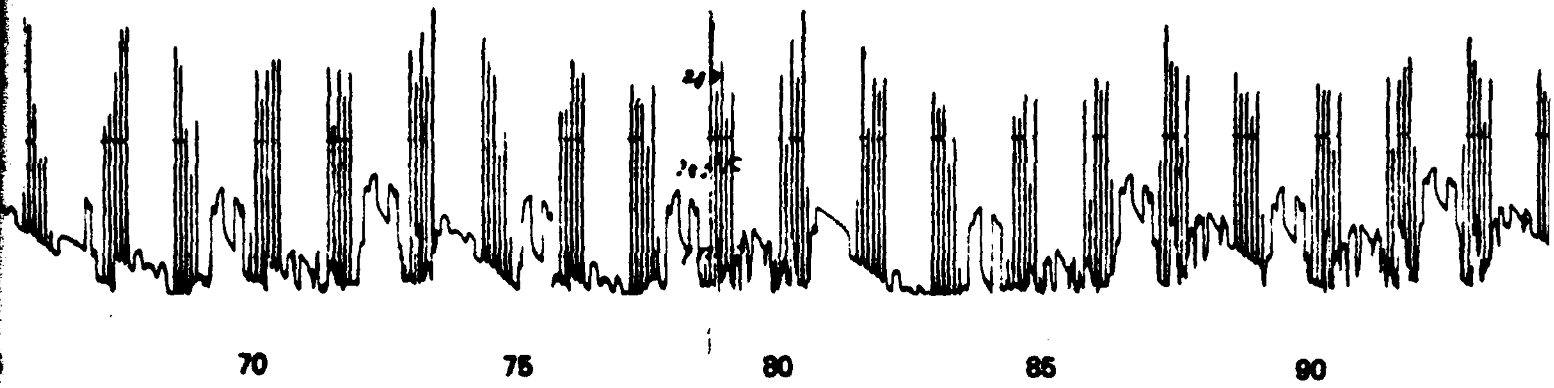

20
25
30
35
40
45

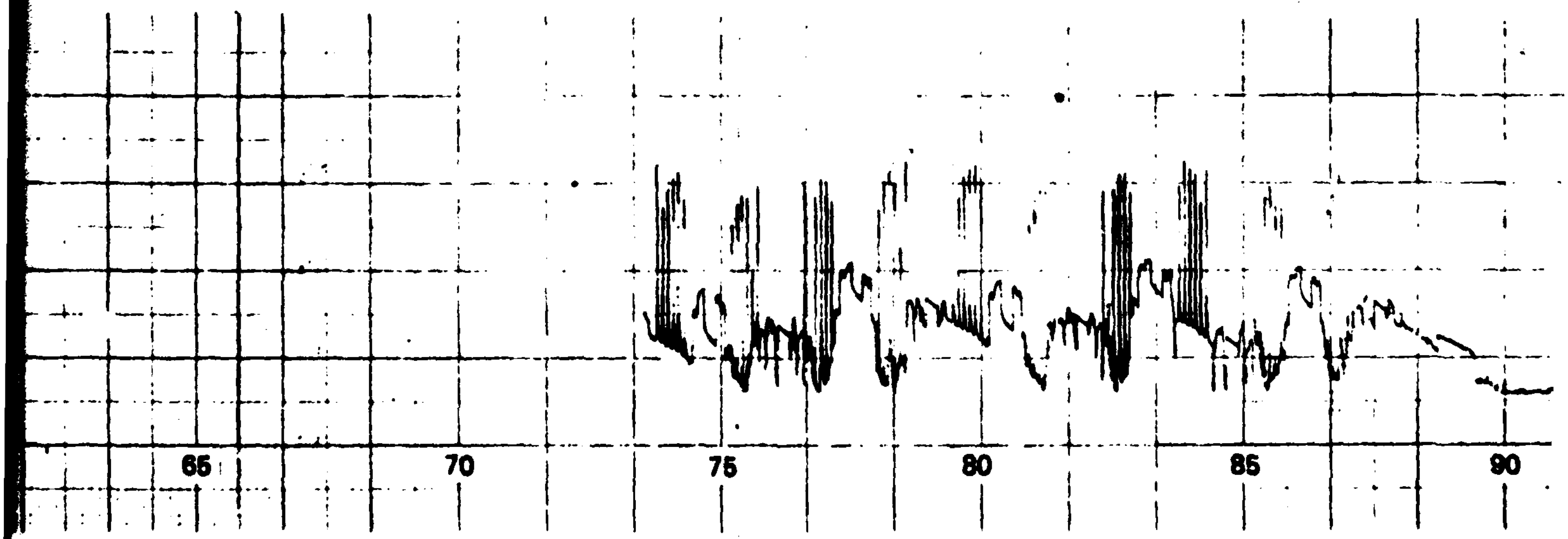

20
25
30
35
40

RF CURE TIME – TEMPERATURE PROFILE









4

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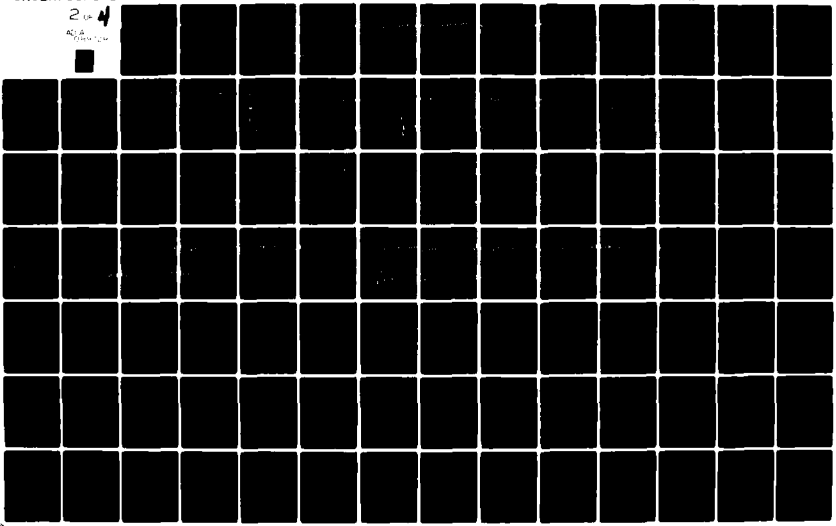
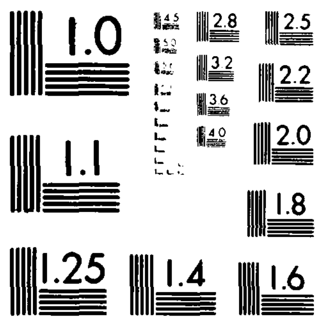
CONVEYORIZED RADIO FREQUENCY CURE OF EPOXY GLASS COMPOSITES.(U)

MAY 80 L C RITTER   DAAG46-79-C-0009

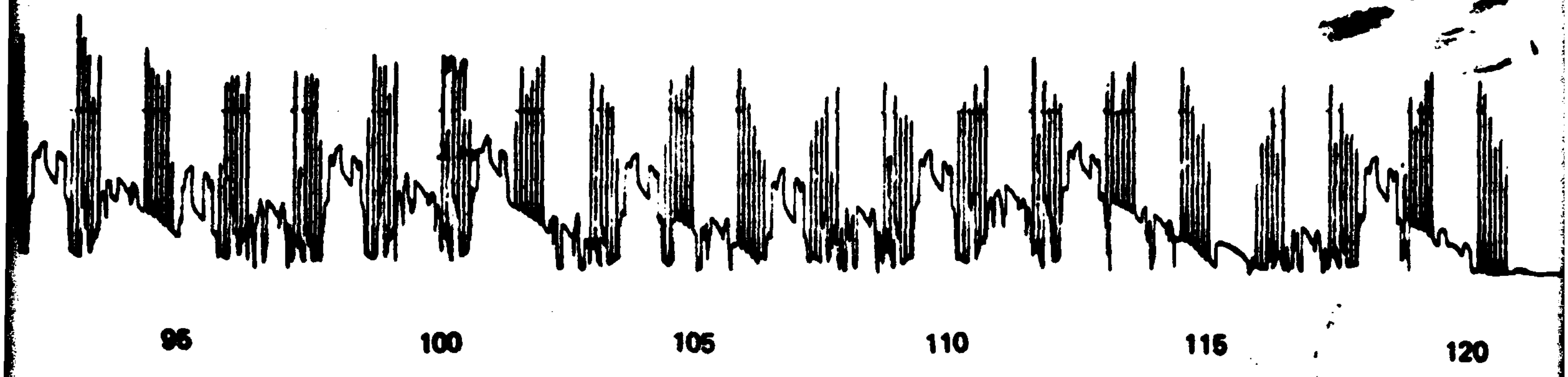
UNCLASSIFIED   USAAVRADCOM-TR-80-F-16   NL

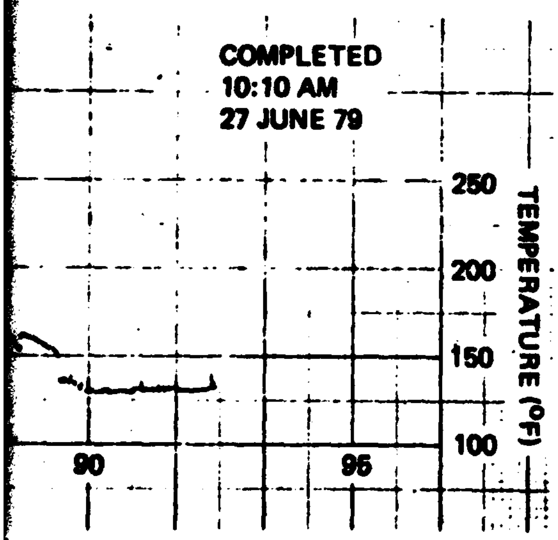
2 of 4

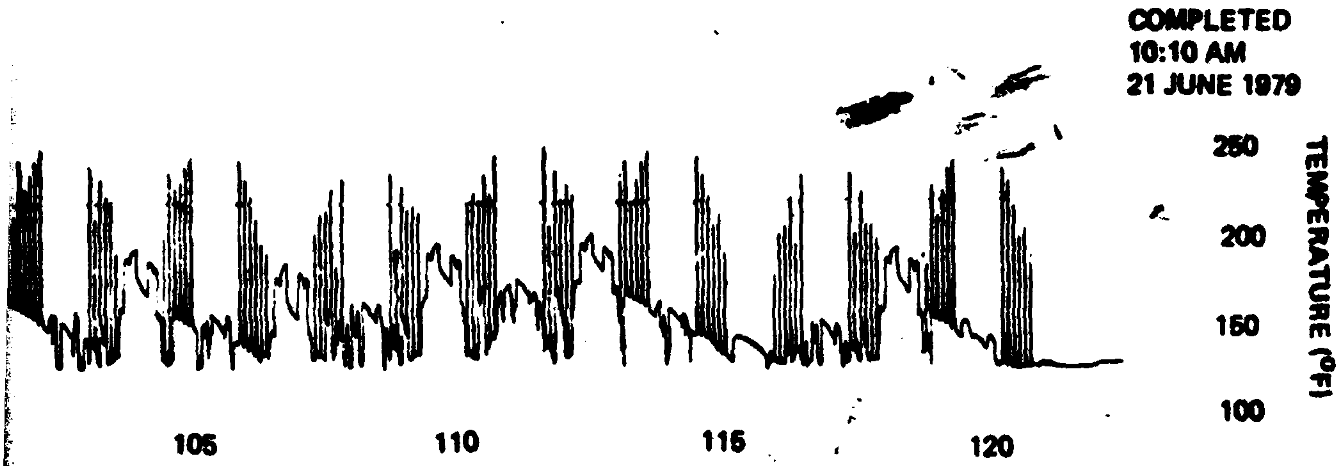




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A


95
100
105
110
115
120


COMPLETED
10:10 AM
27 JUNE 79
250
200
150
100
TEMPERATURE (°F)
90
95


COMPLETED
10:10 AM
21 JUNE 1979
250
200
150
100
TEMPERATURE (°F)
105
110
115
120

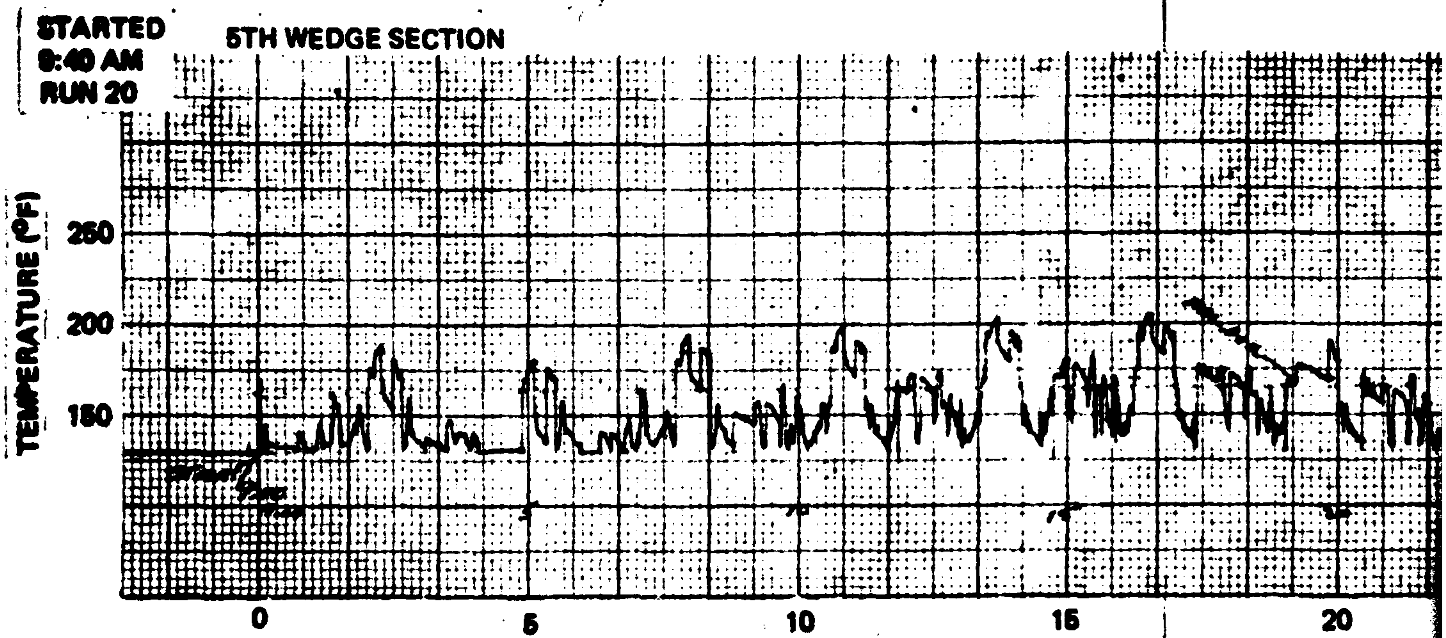


Figure E–7. Temperature Printout for 5th Wedge Section (Run Number 20)

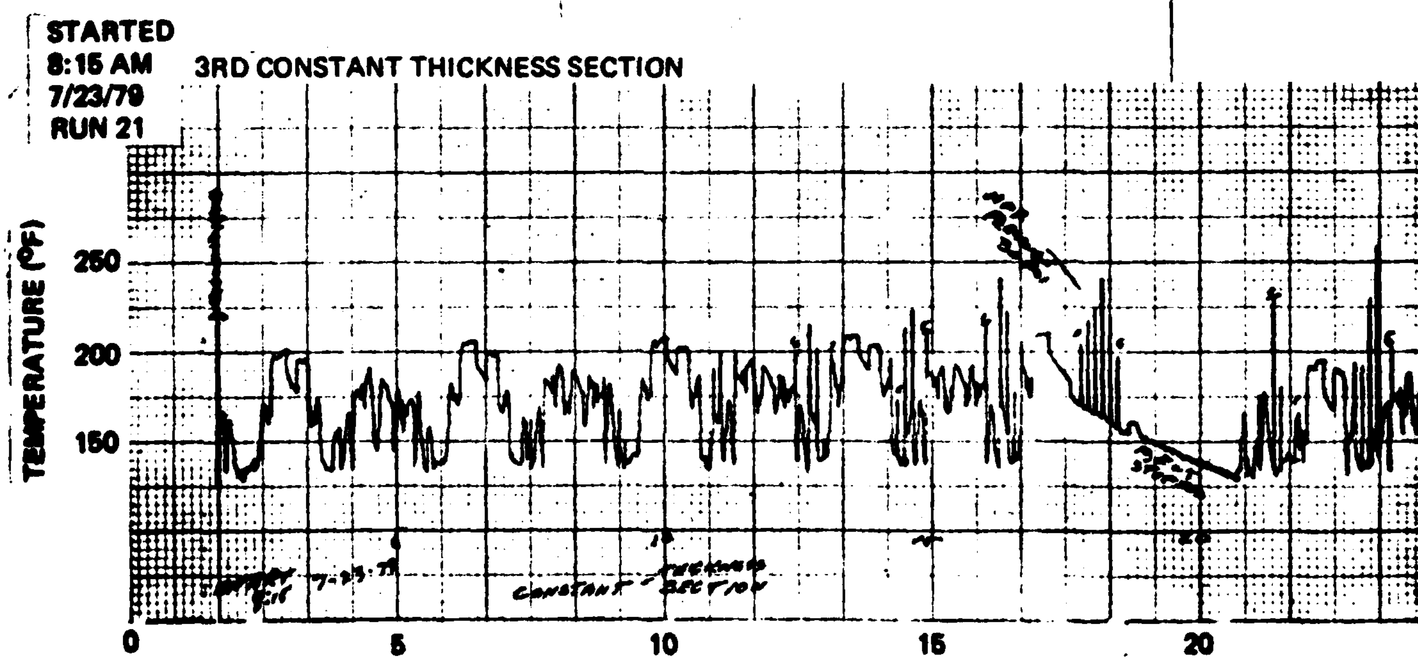
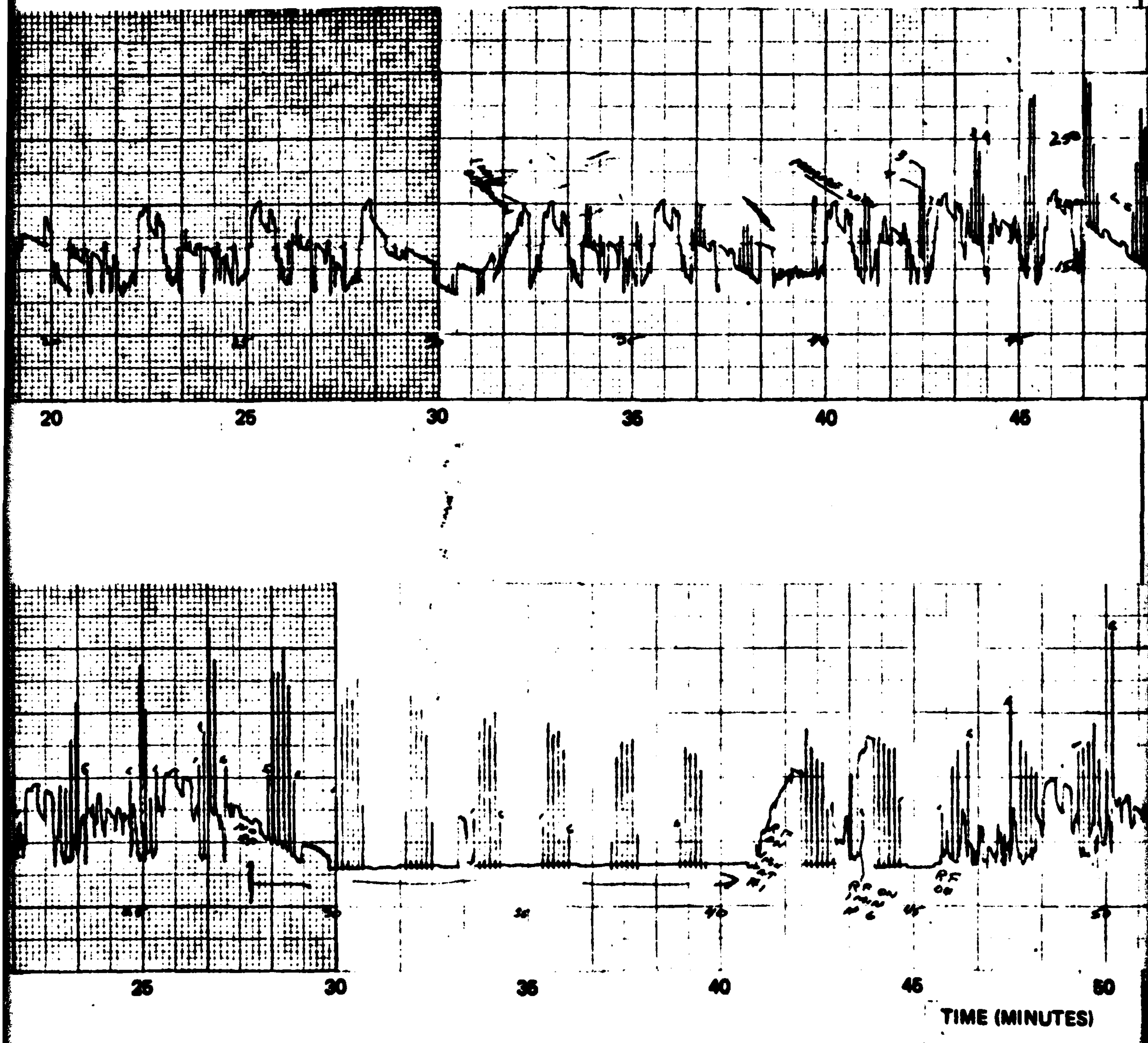
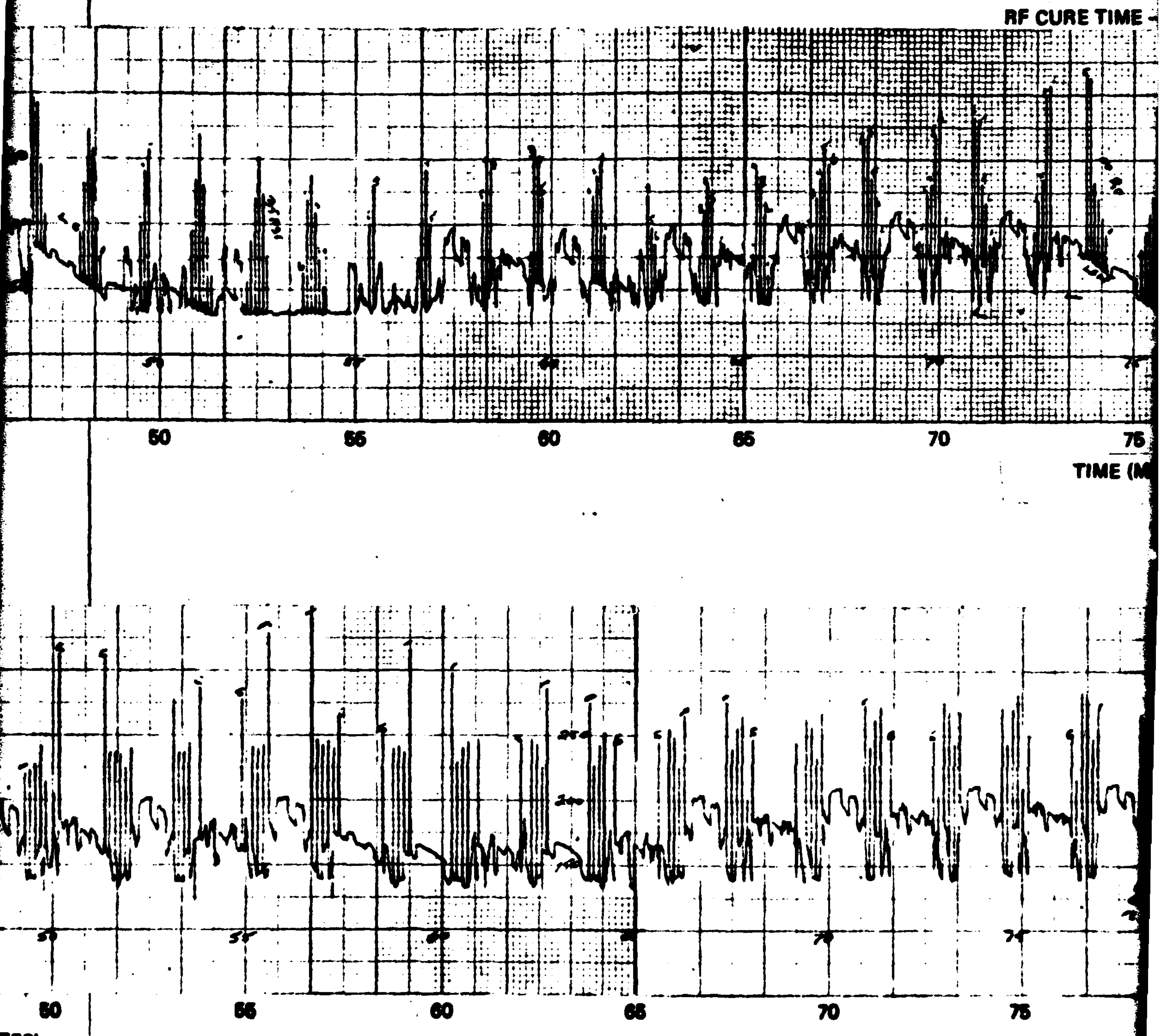
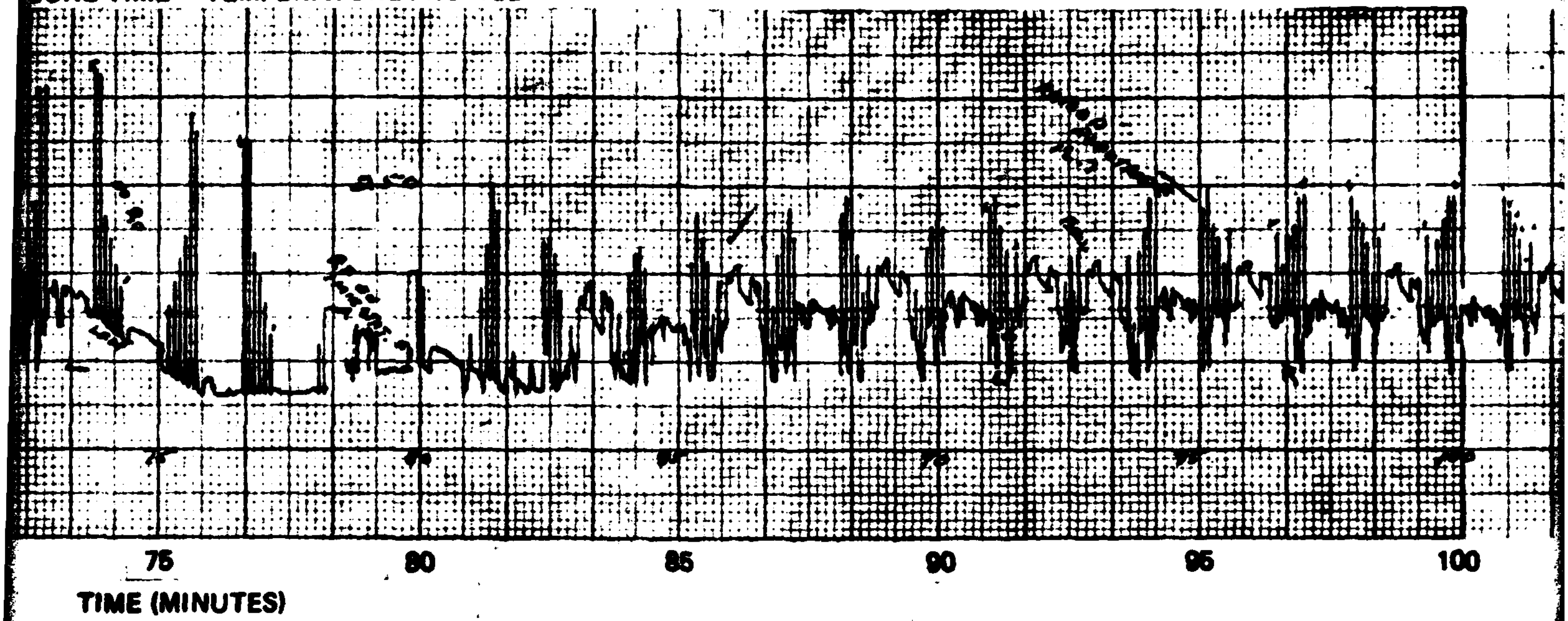


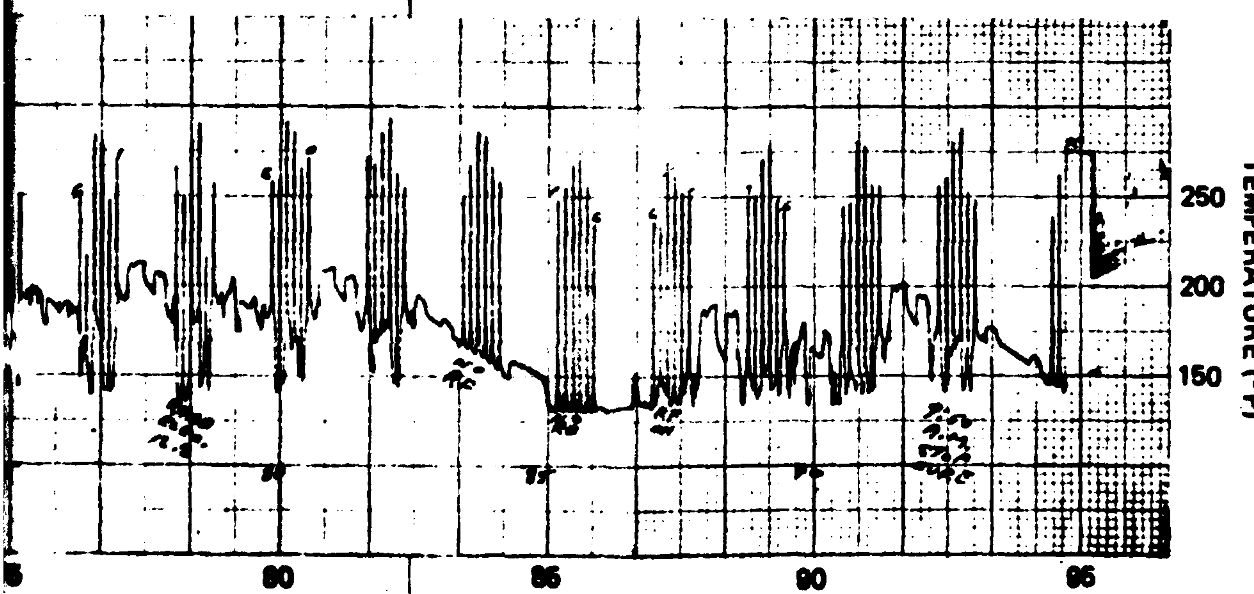
Figure E–8. Temperature Printout for 3rd Constant Thickness Section (Run Number 21)

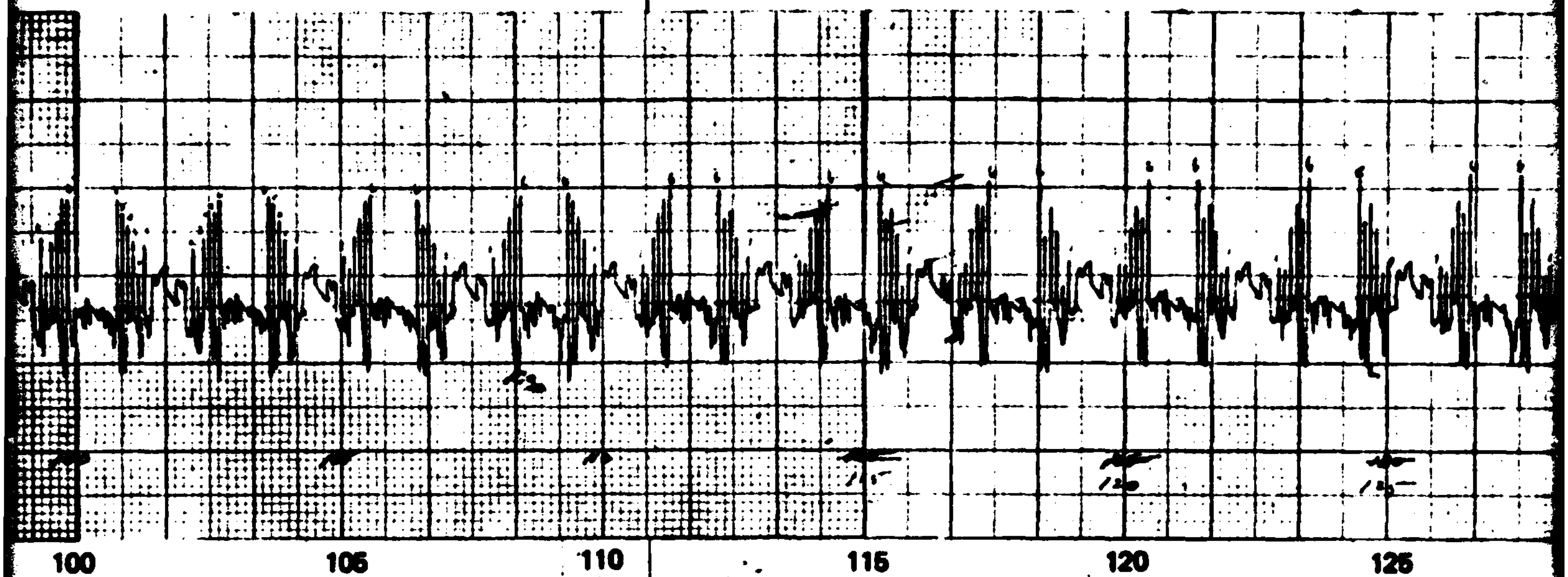

20
25
30
35
40
45
25
30
35
40
45
50
TIME (MINUTES)

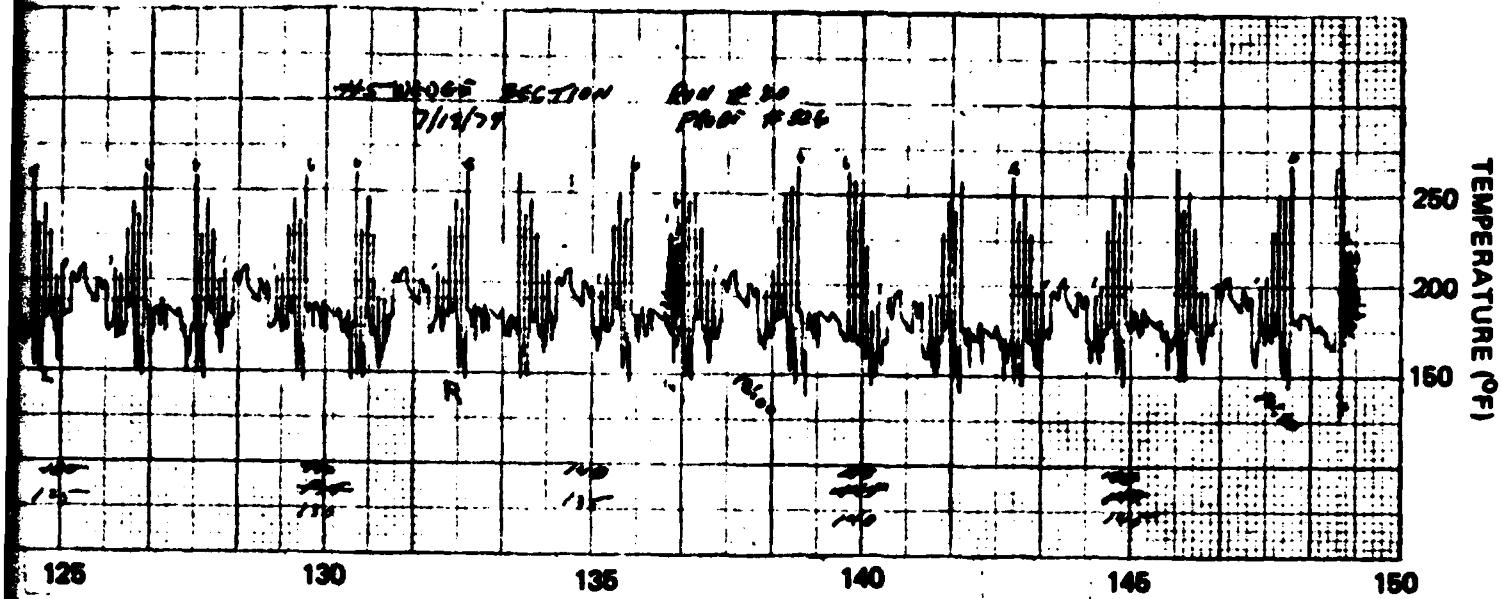

RF CURE TIME -
50
55
60
65
70
75
TIME (M
50
55
60
65
70
75
TES)

CURE TIME – TEMPERATURE PROFILE






100
105
110
115
120
125



, 6

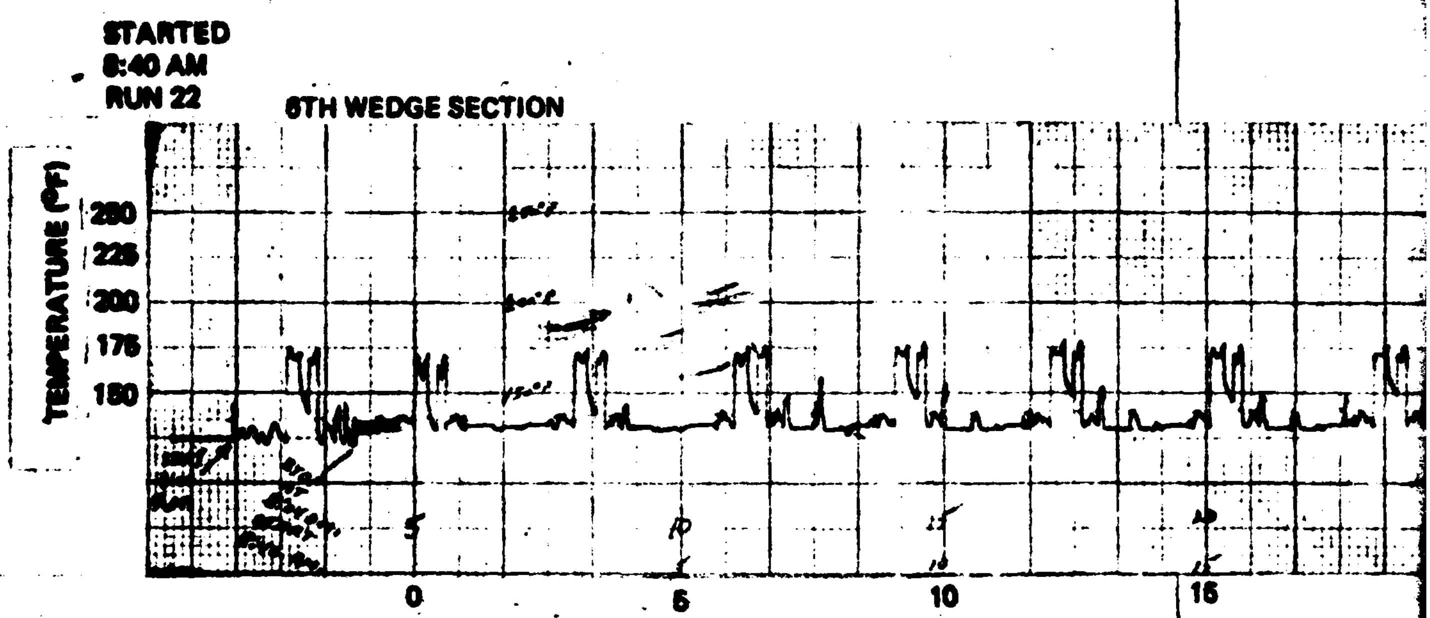


Figure E–9. Temperature Printout for 6th Wedge Section (Run Number 22)

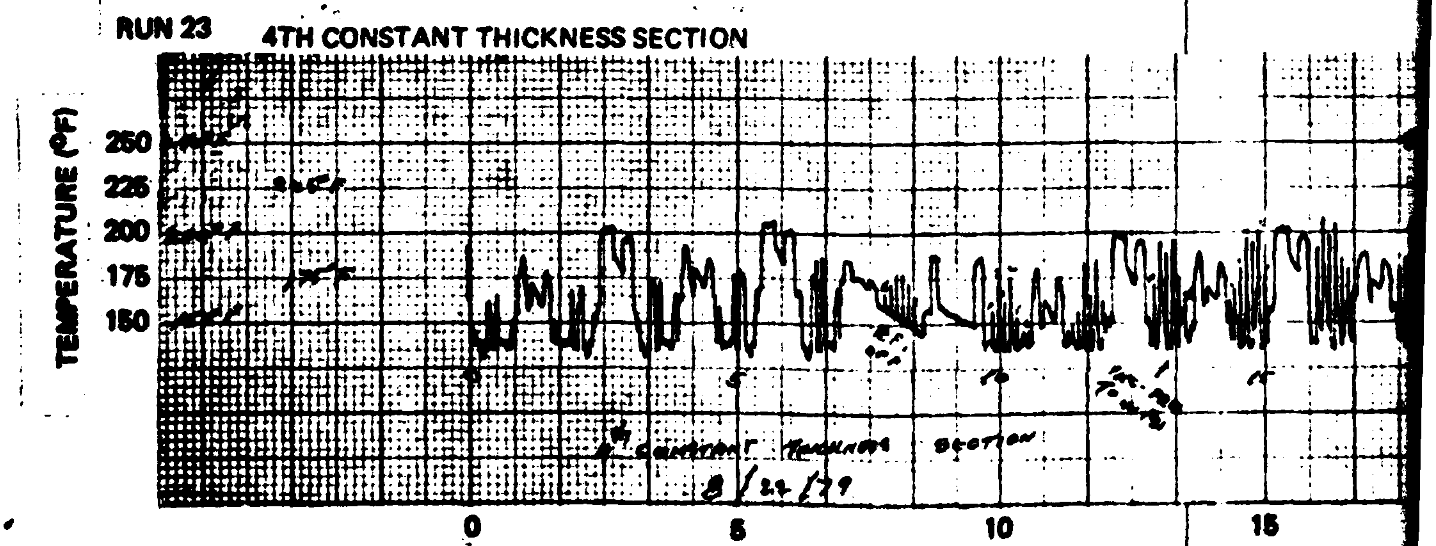
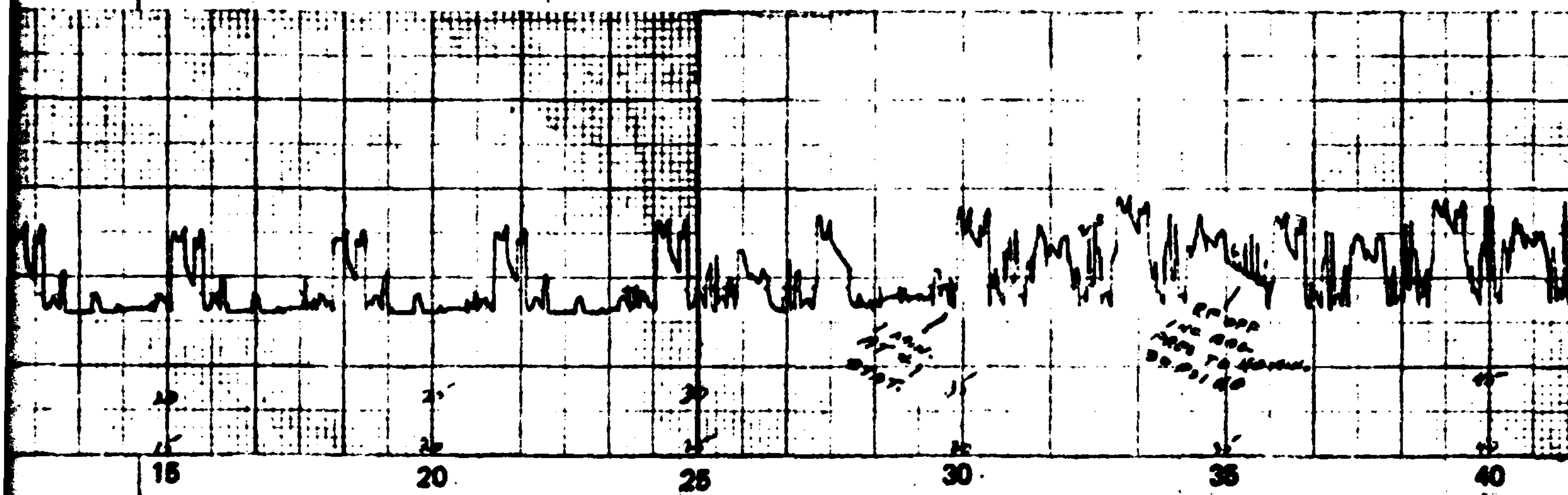
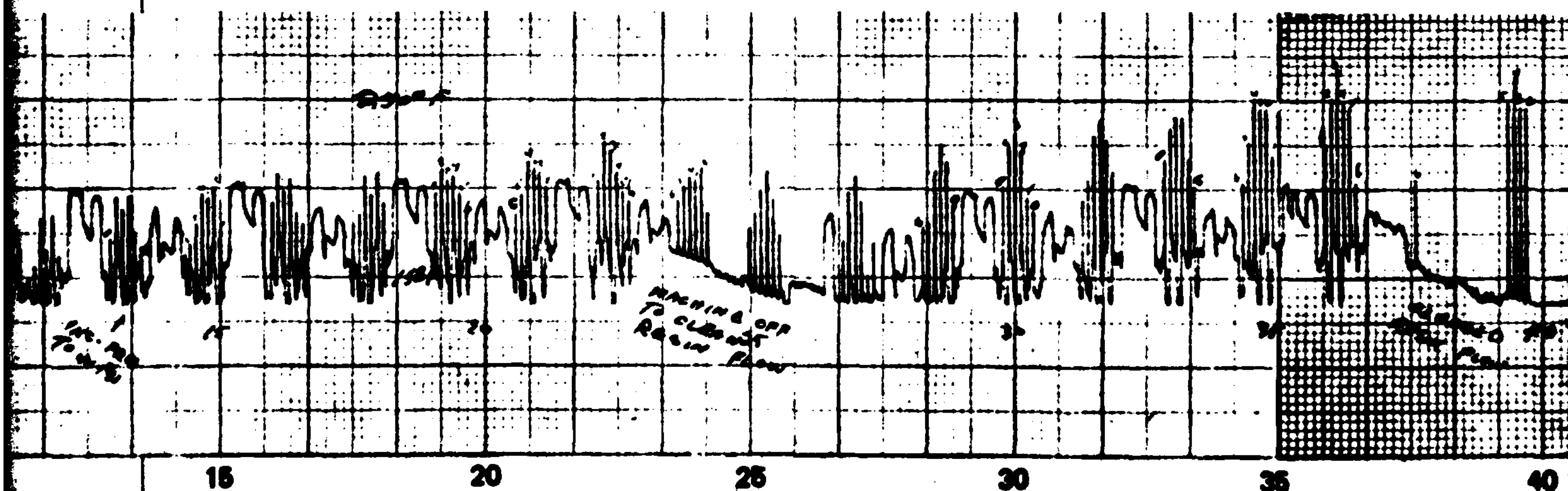
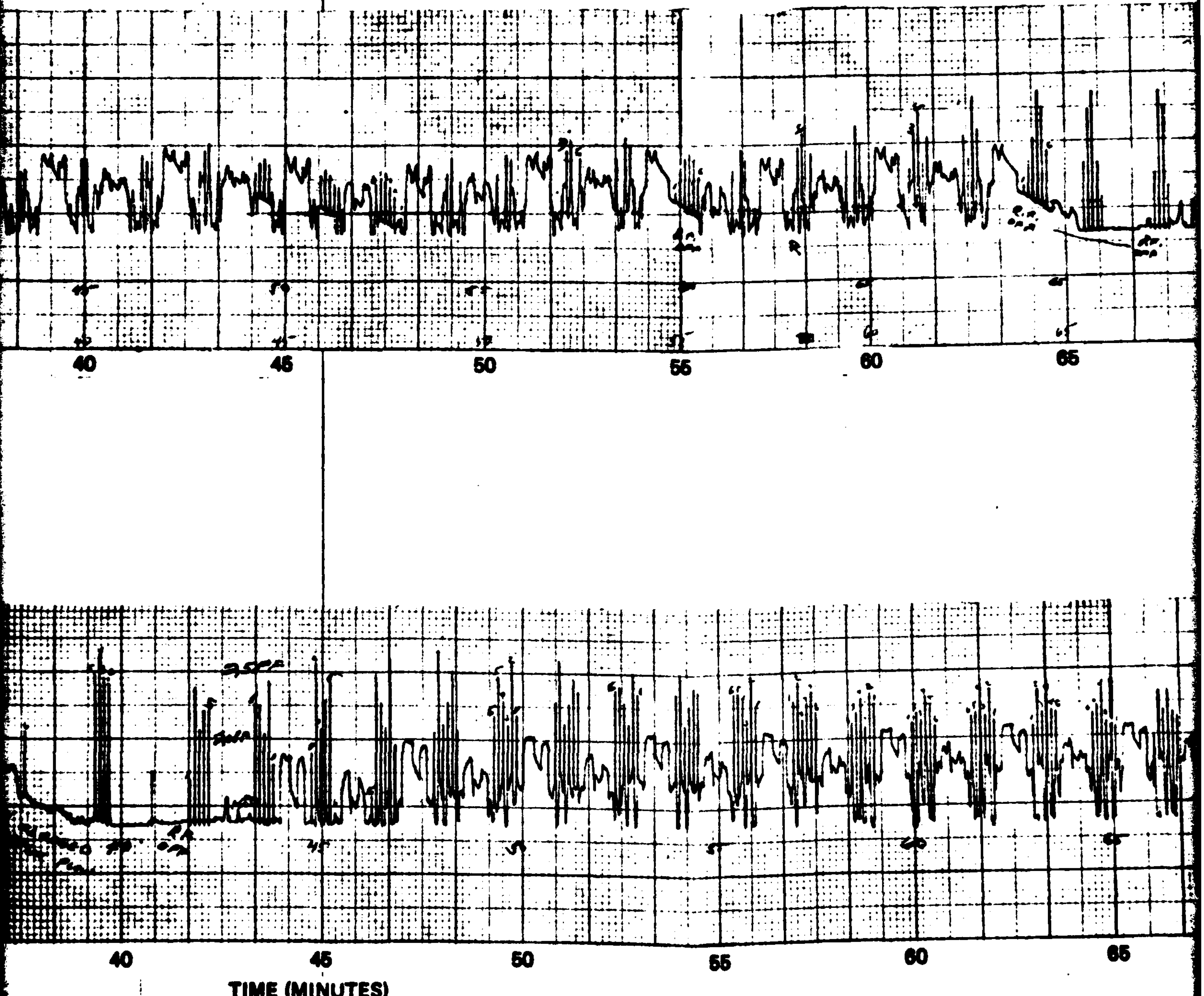


Figure E–10. Temperature Printout for 4th Constant Thickness Section (Run Number 23)



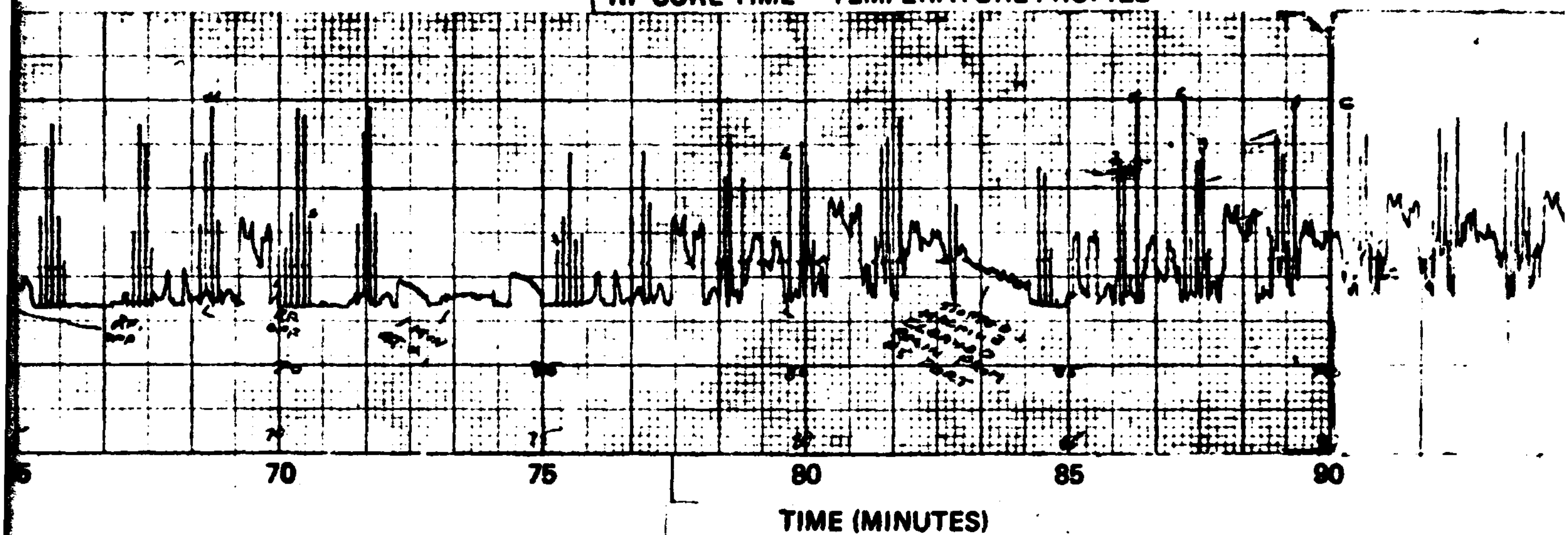


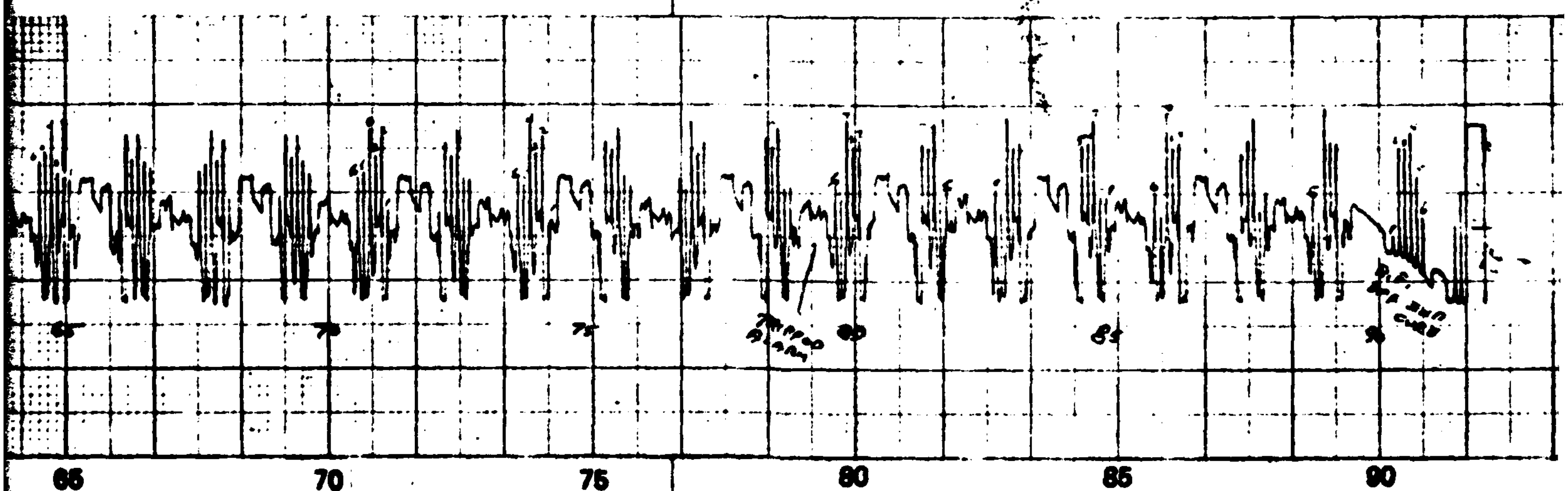
23)

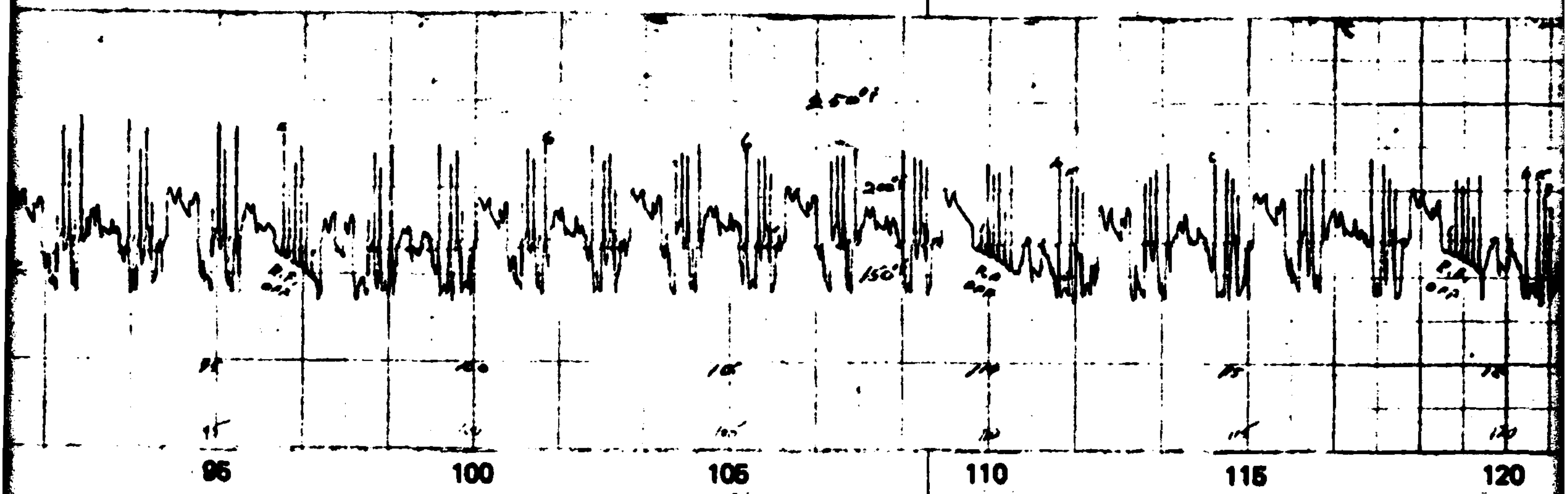


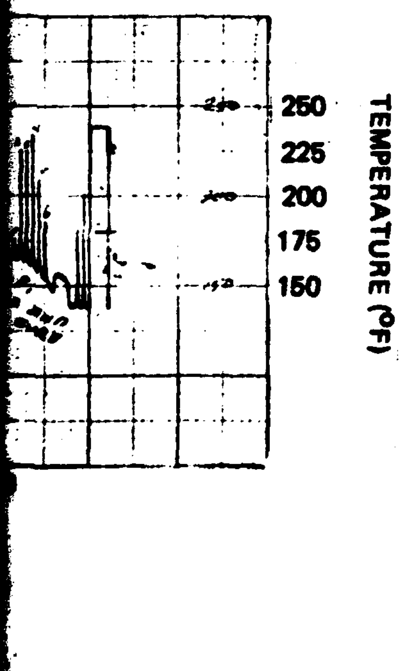
3

RF CURE TIME – TEMPERATURE PROFILE

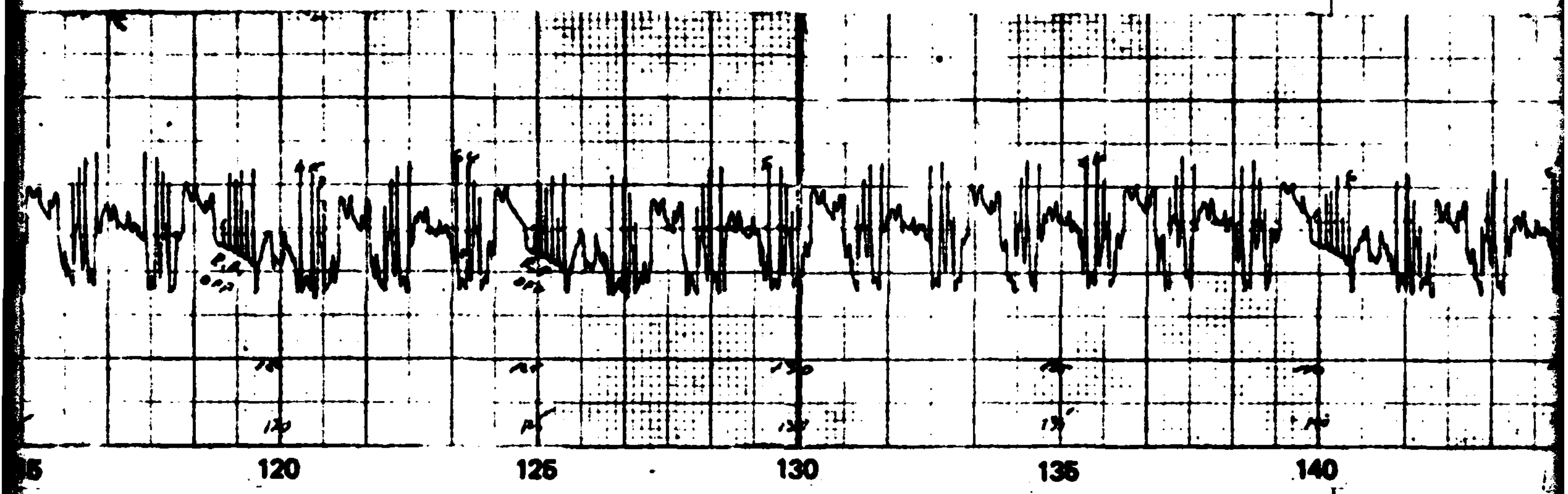




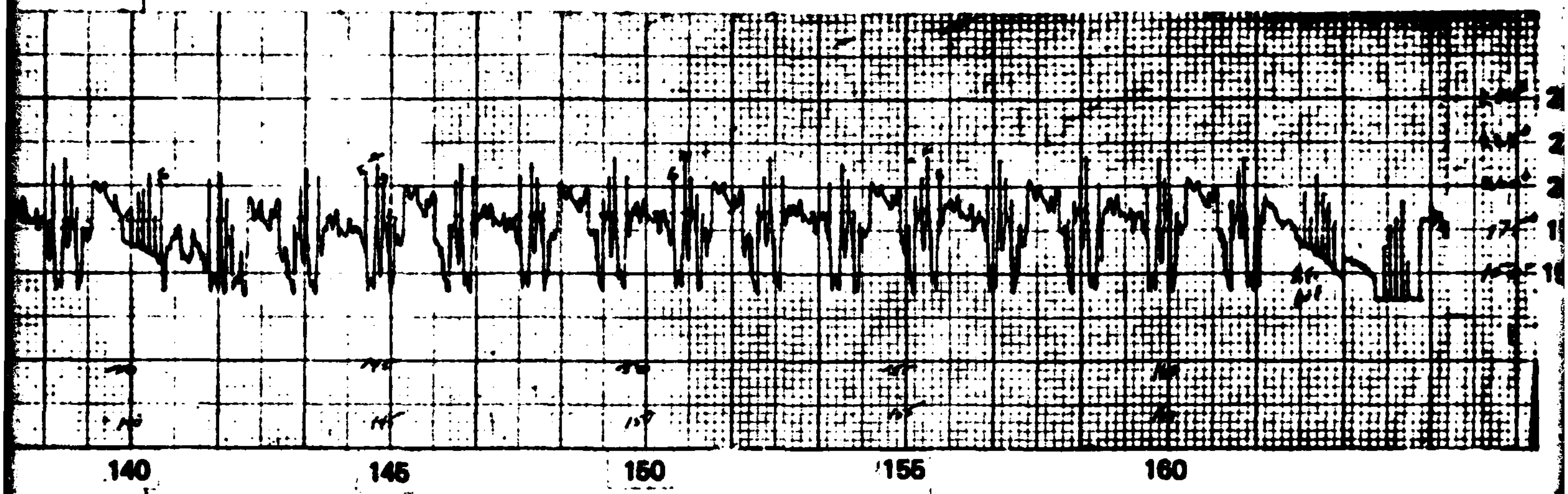




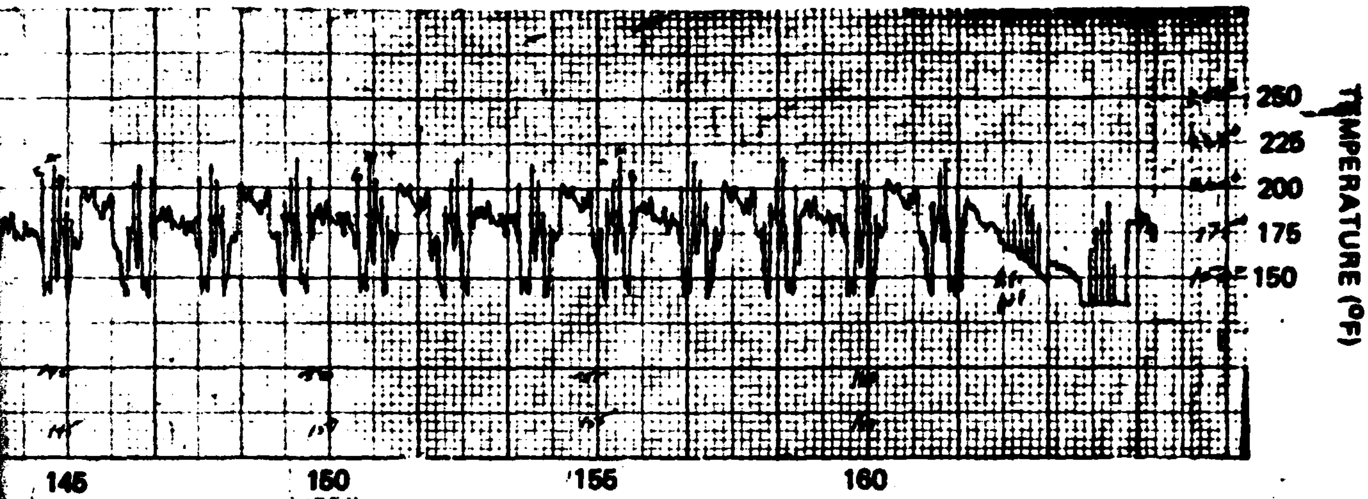
15



120
125
130
135
140



140
145
150
155
160


250
225
200
175
150
TEMPERATURE (°F)
145
150
155
160

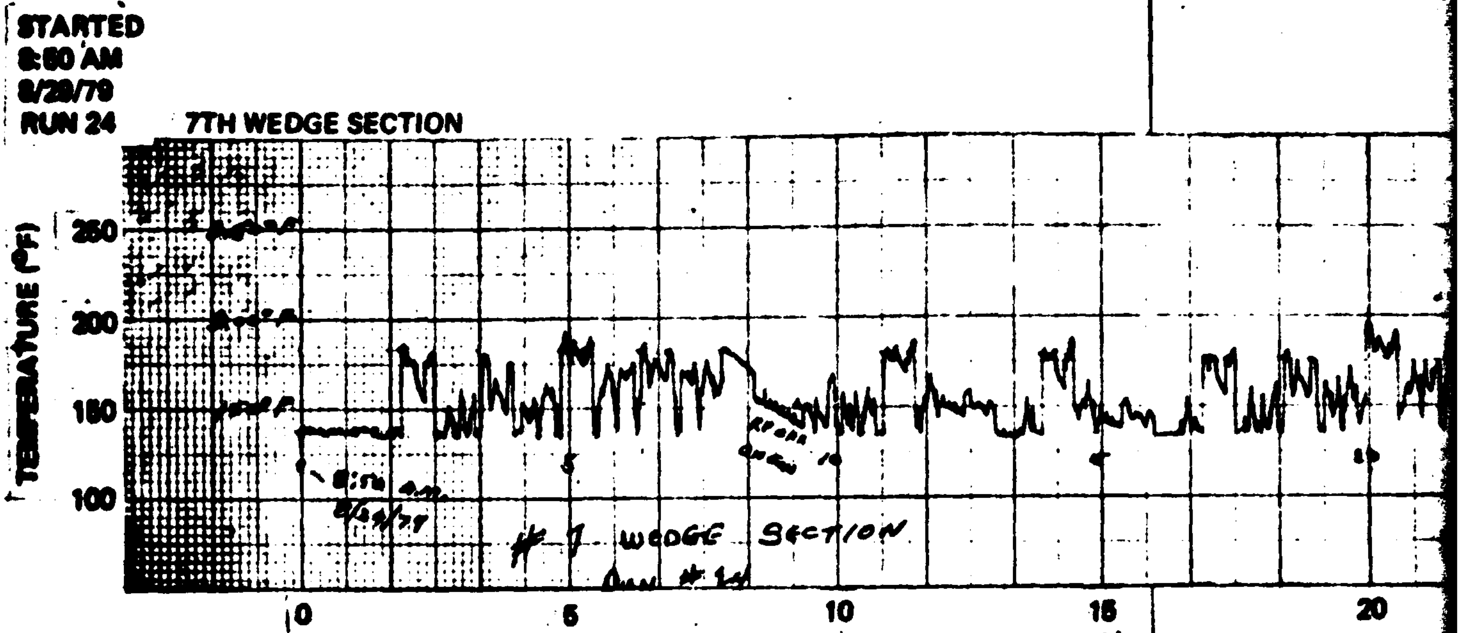


Figure E–11. Temperature Printout for 7th Wedge Section (Run Number 24)

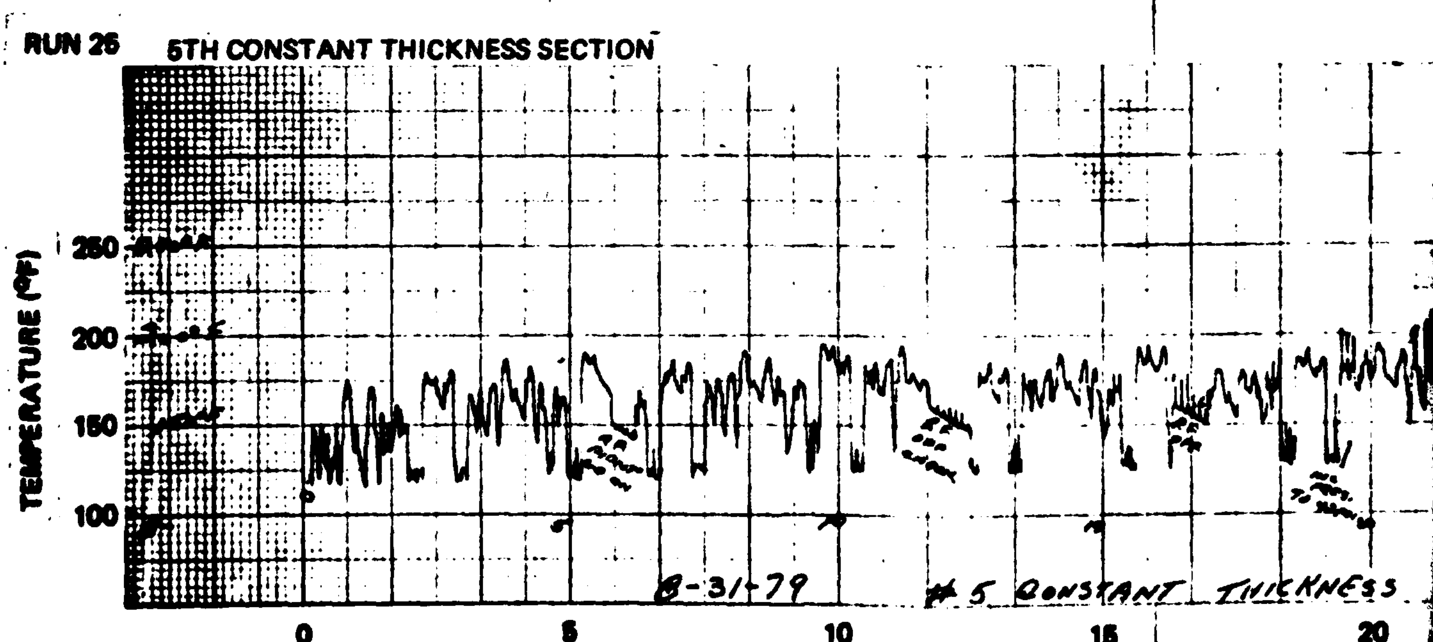
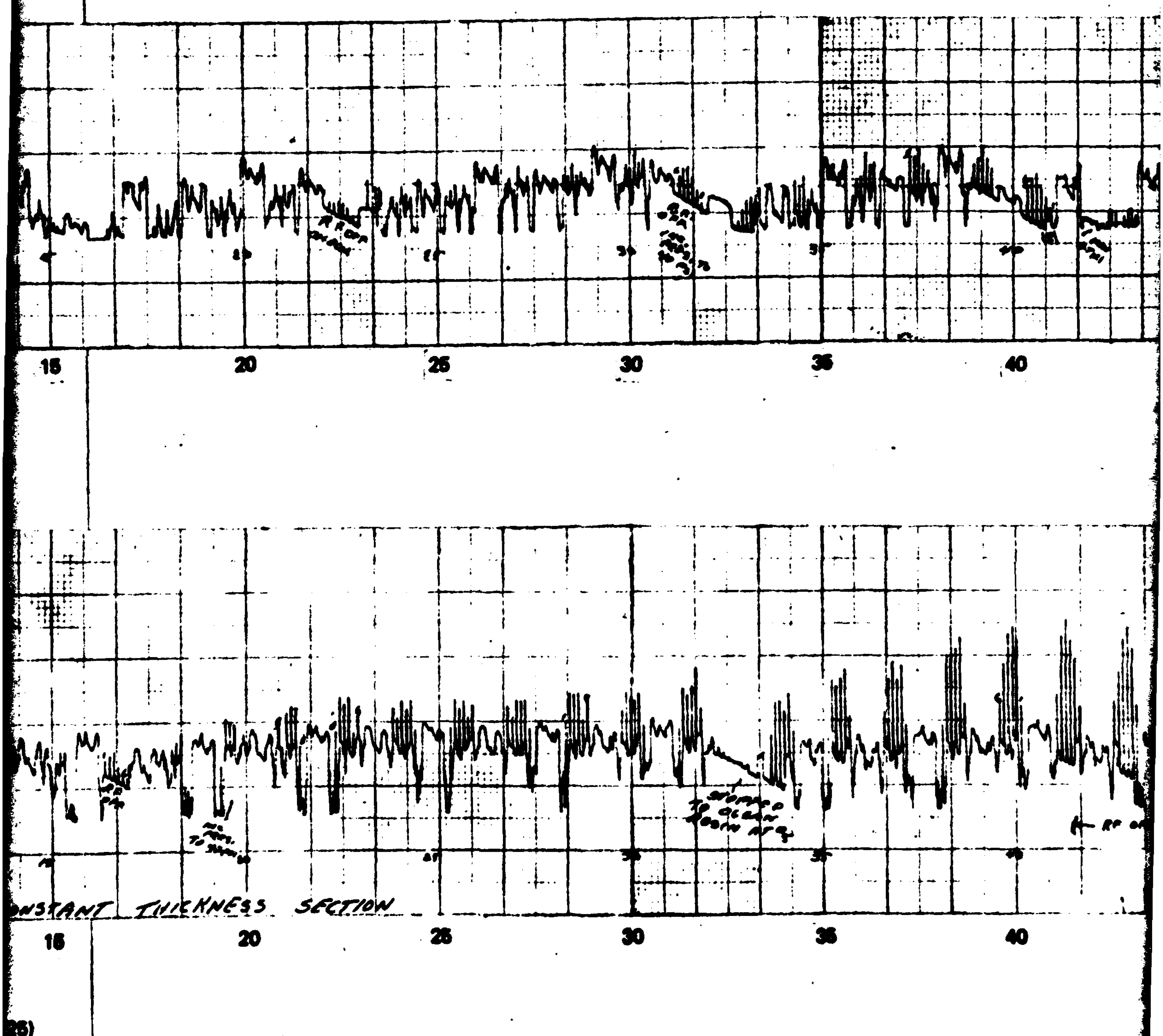
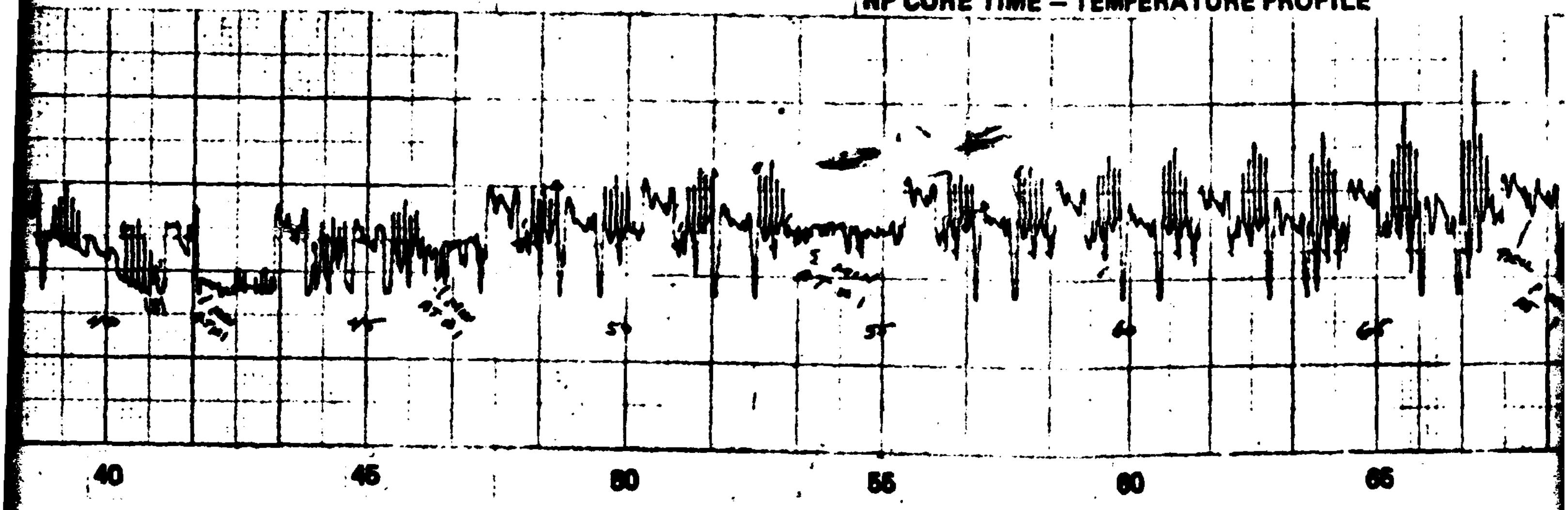


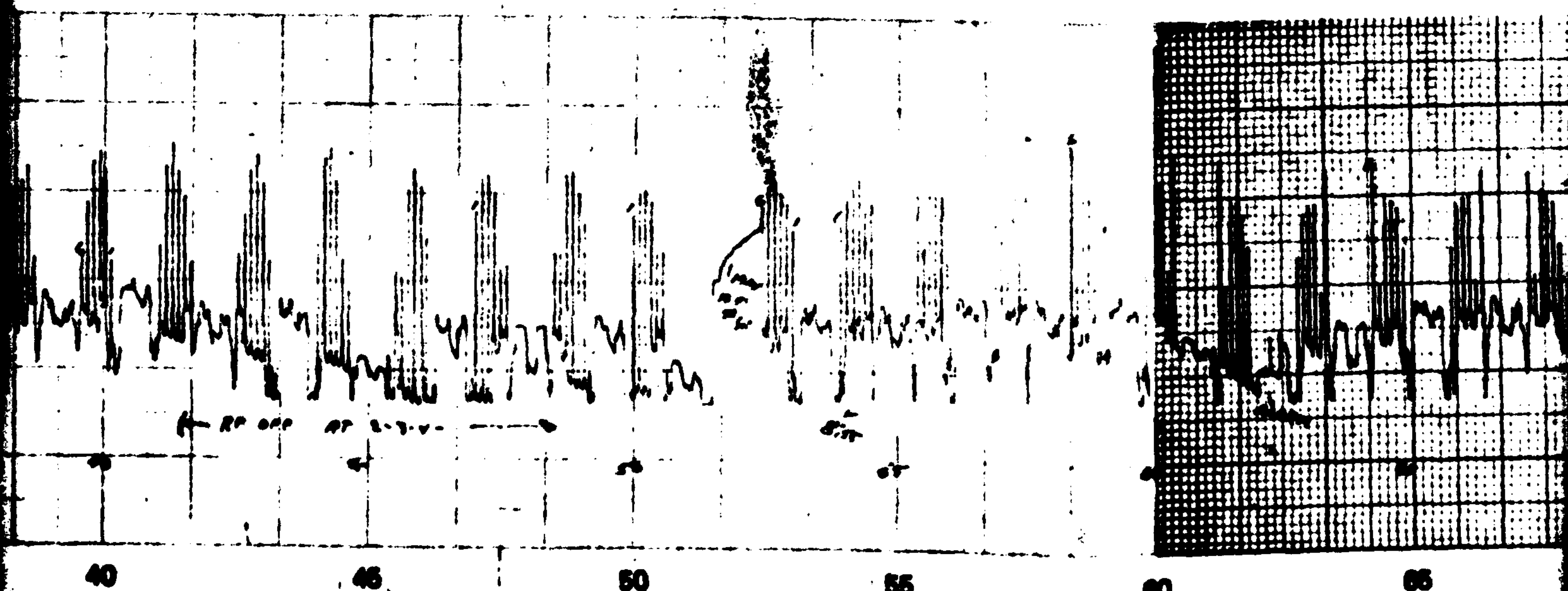
Figure E–12. Temperature Printout for 5th Constant Thickness Section (Run Number 25)


15 20 25 30 35 40
15 20 25 30 35 40
NSTANT THICKNESS SECTION
25)

RF CURE TIME – TEMPERATURE PROFILE

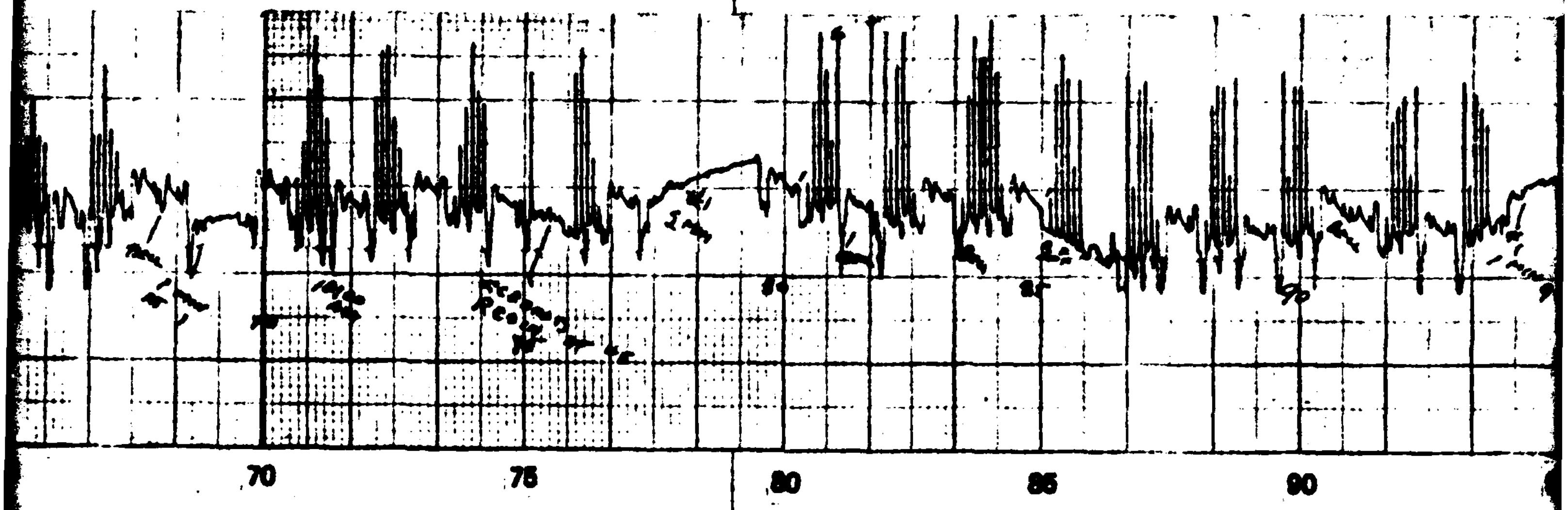


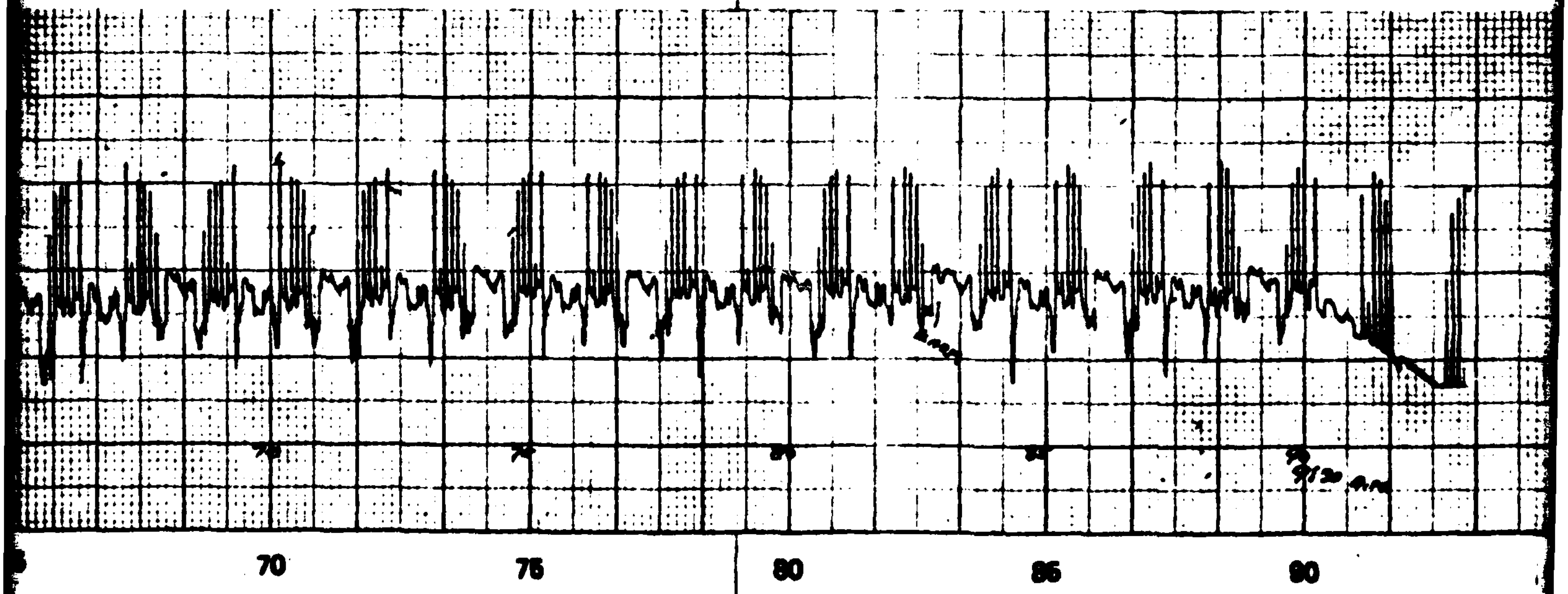
TIME (MINUTES)



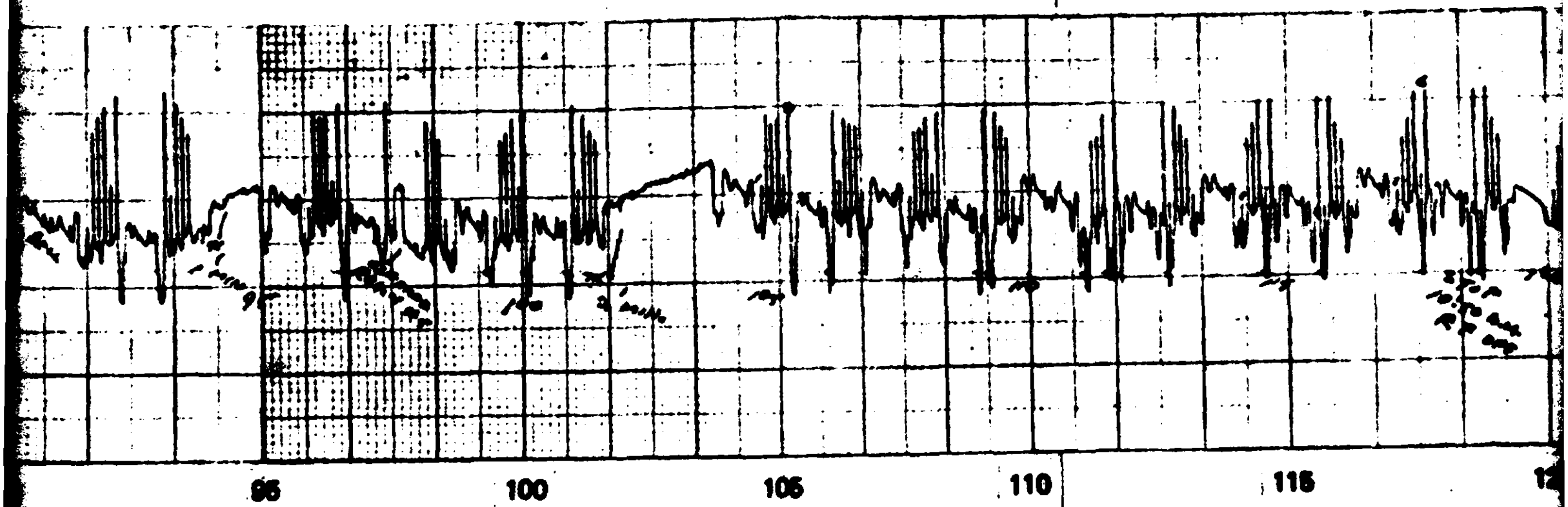
TIME (MINUTES)

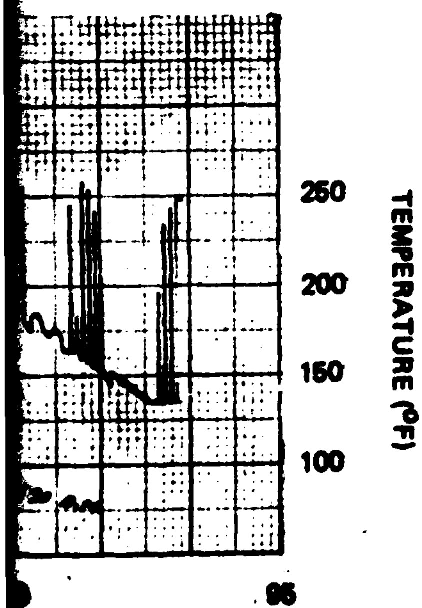
3



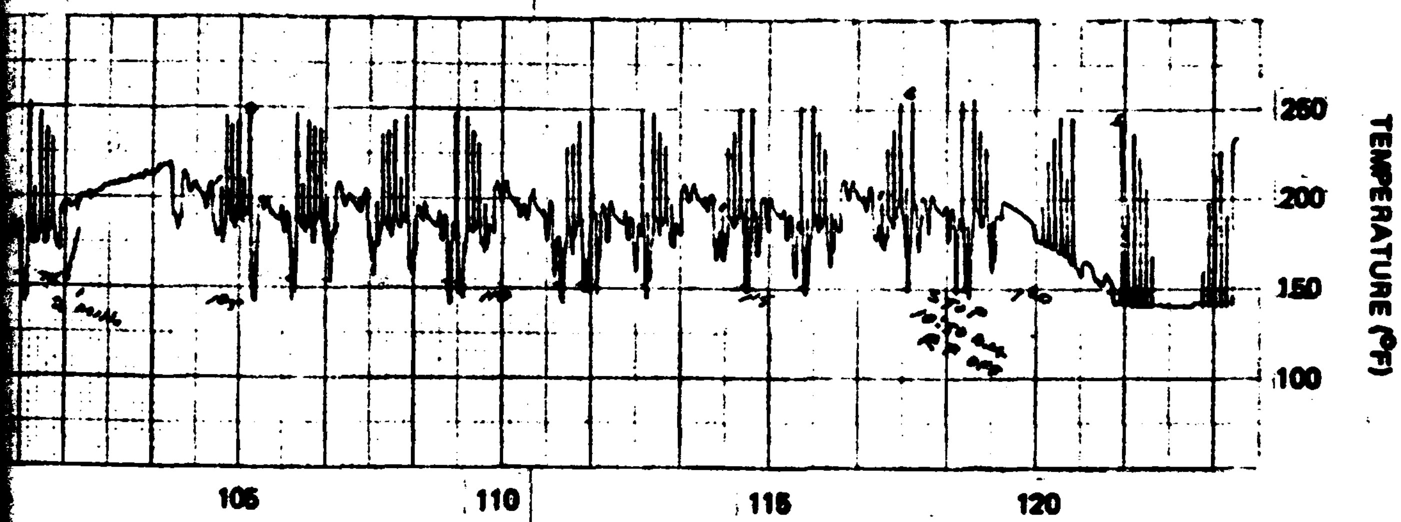


124





15



250
200
150
100
TEMPERATURE (°F)
105
110
115
120

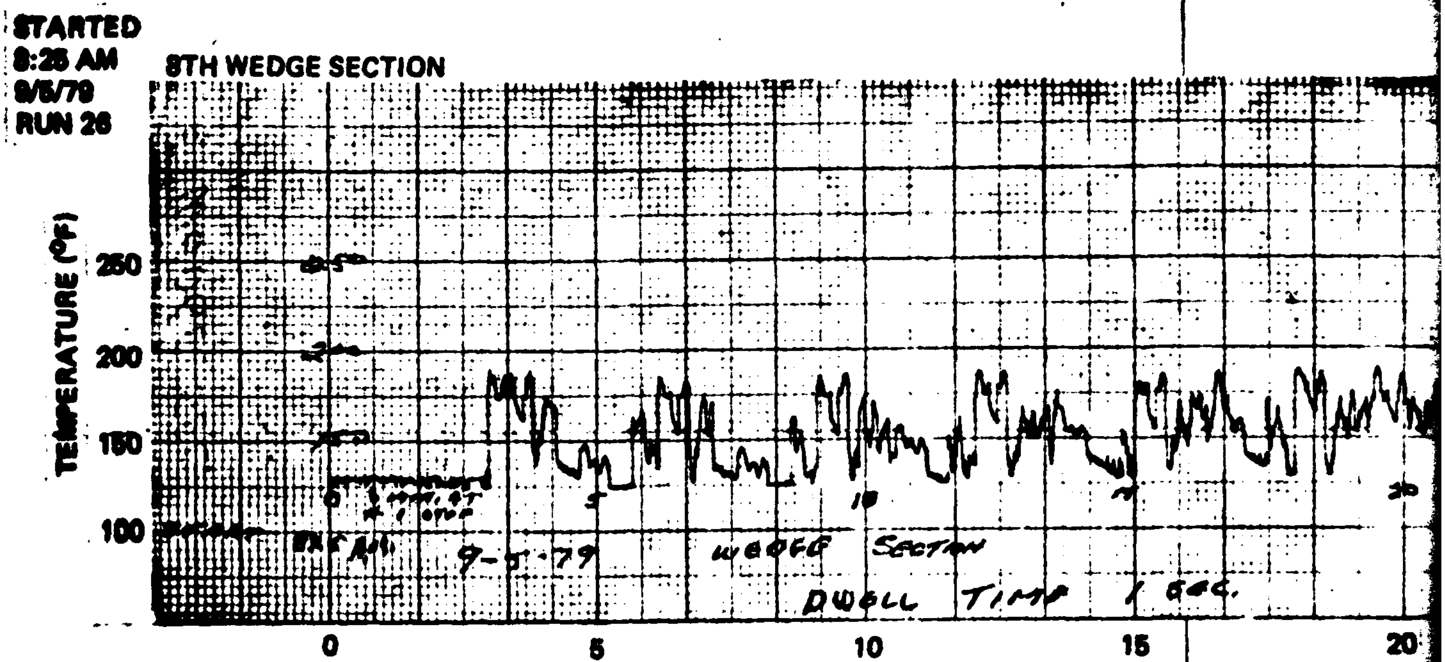


Figure E–13. Temperature Printout for 8th Wedge Section (Run Number 26)

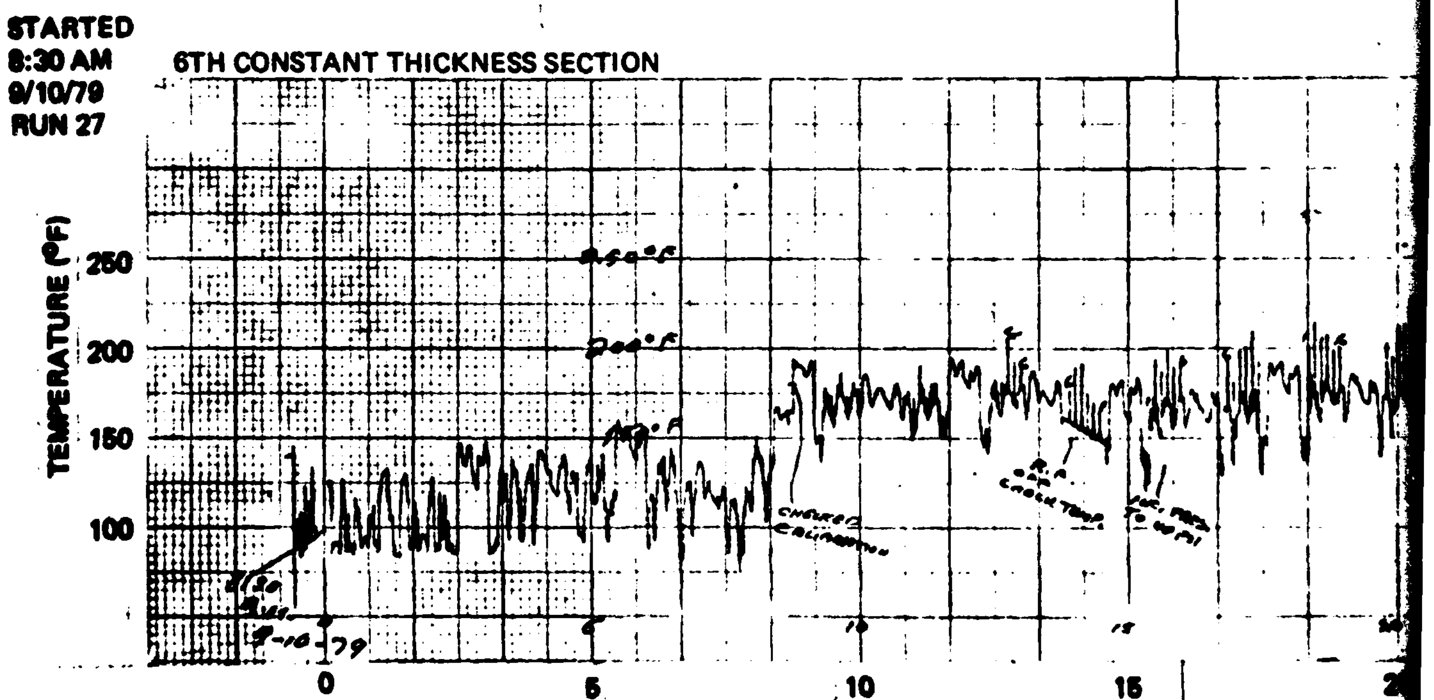
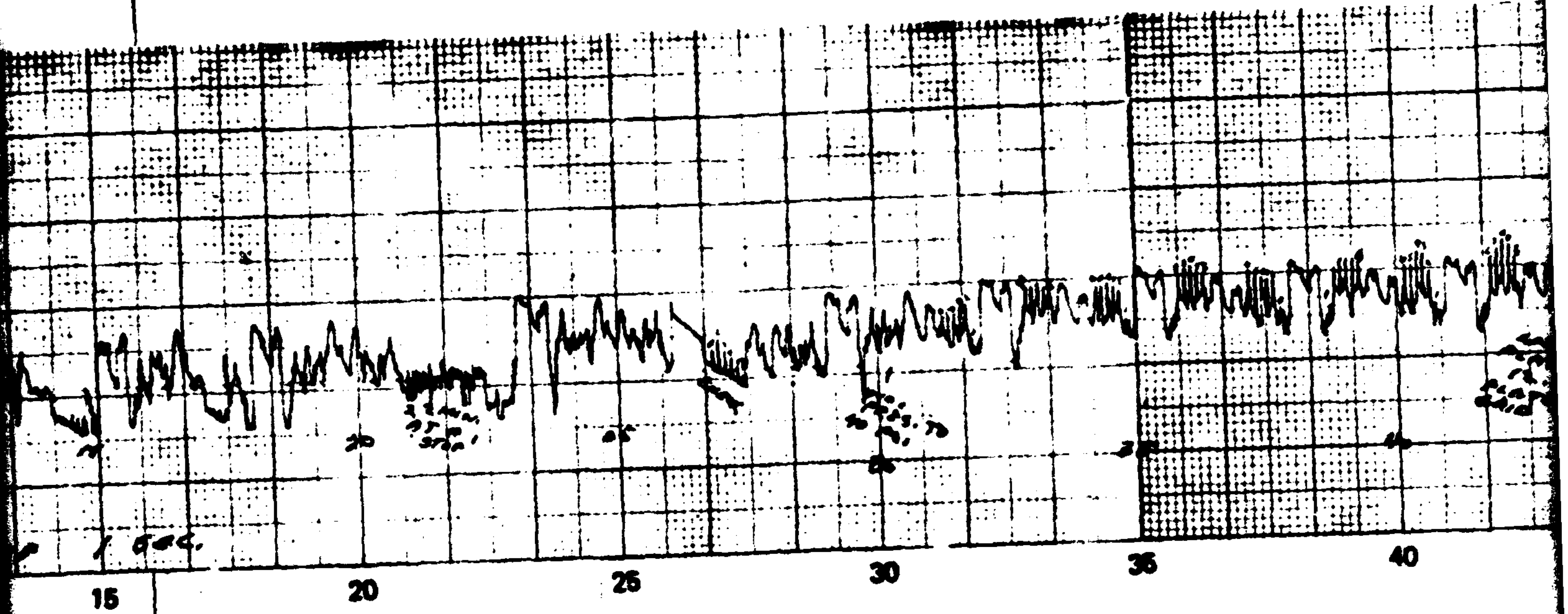
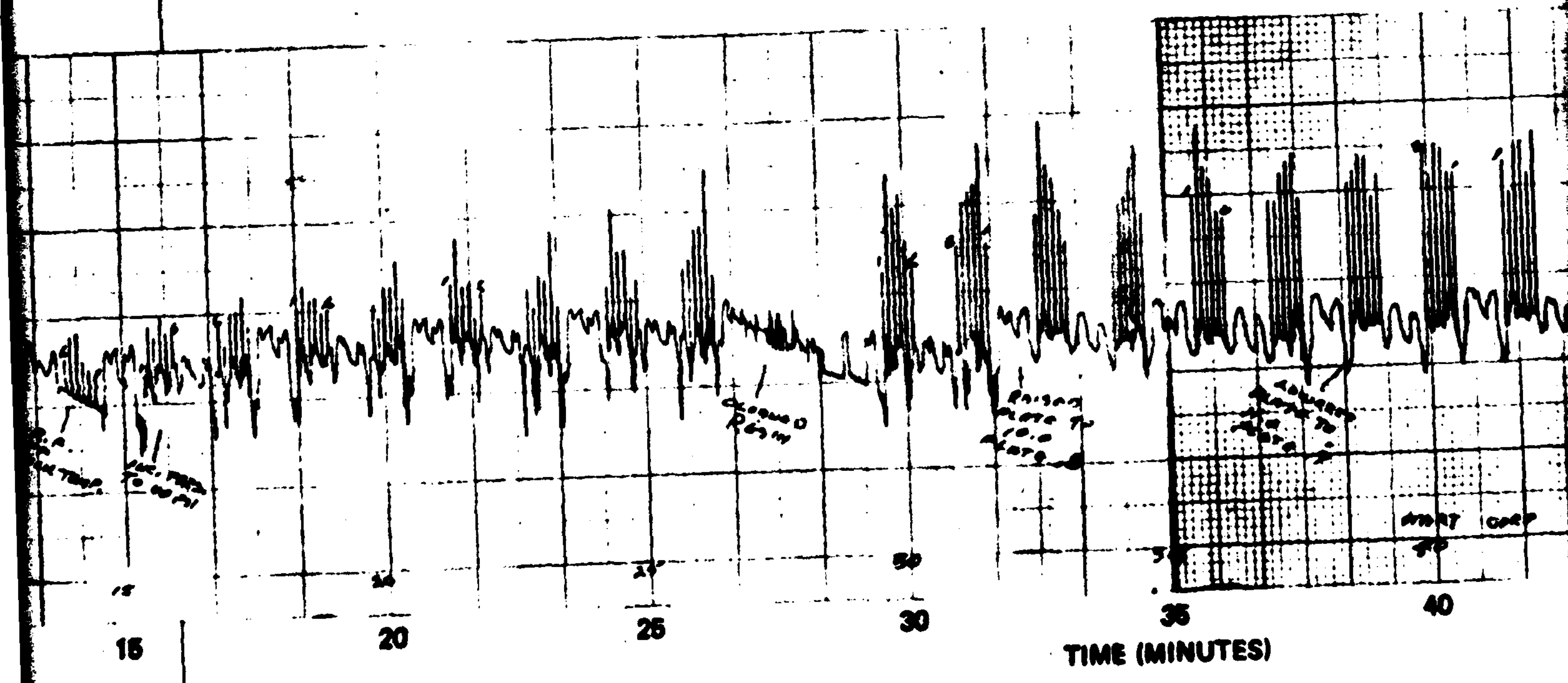


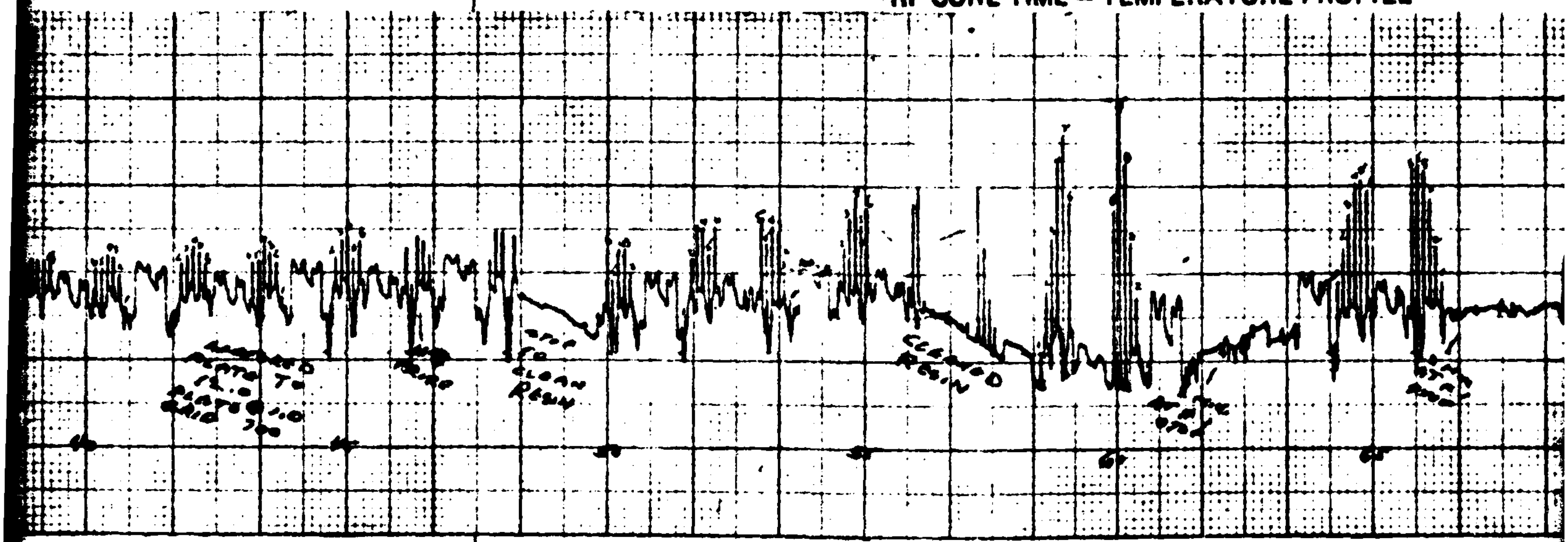
Figure E–14. Temperature Printout for 6th Constant Thickness Section (Run Number 27)

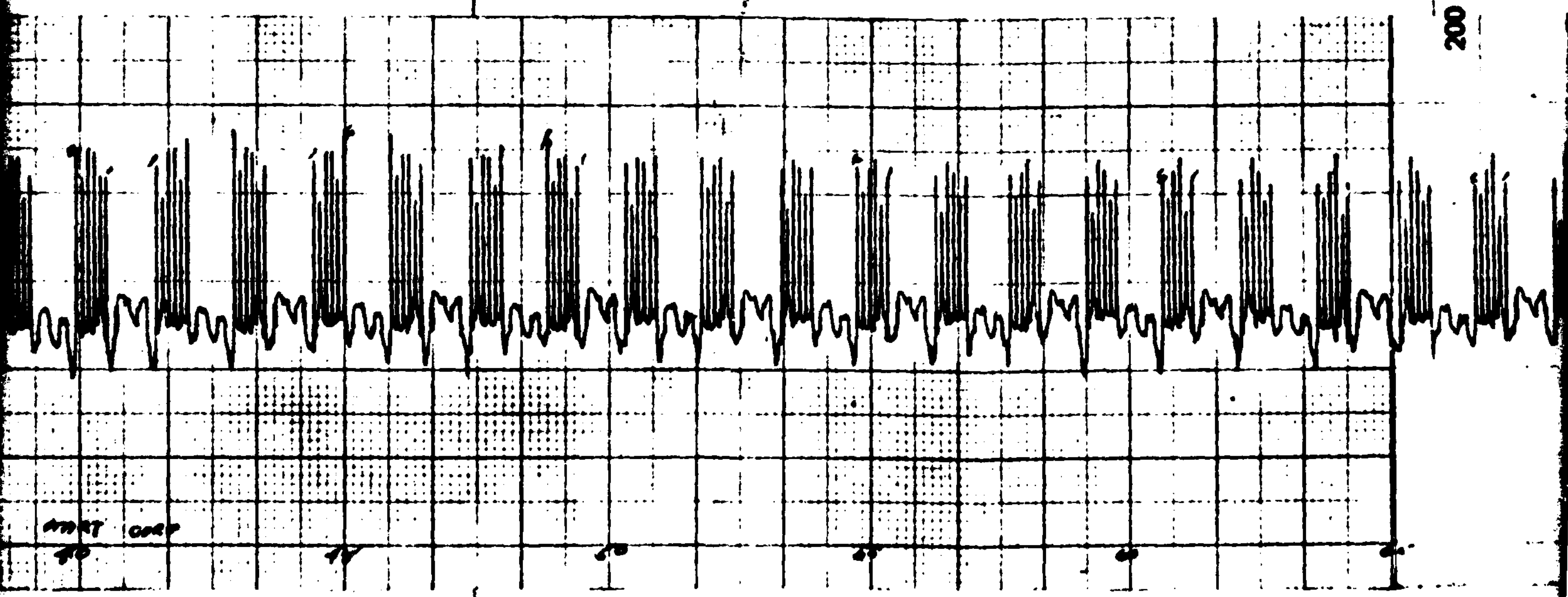




27)

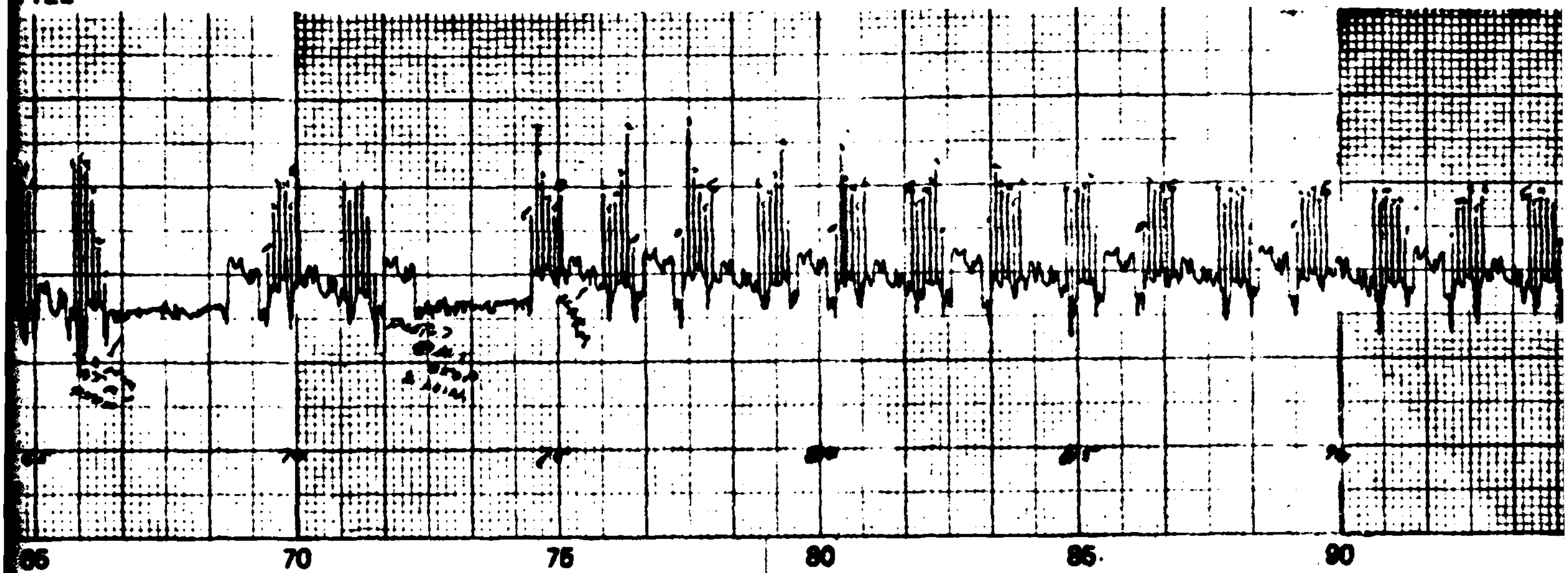
RF CURE TIME – TEMPERATURE PROFILE

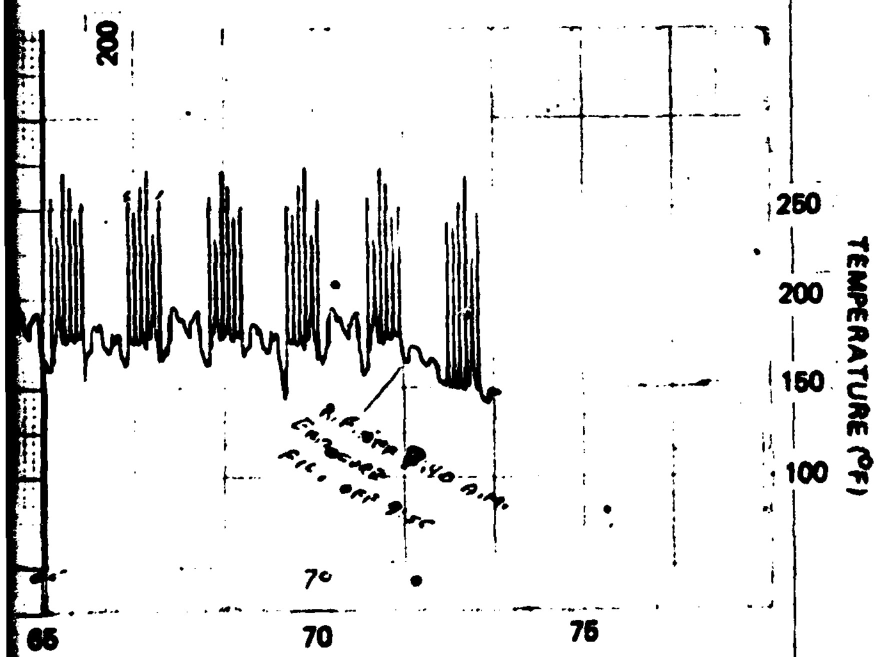




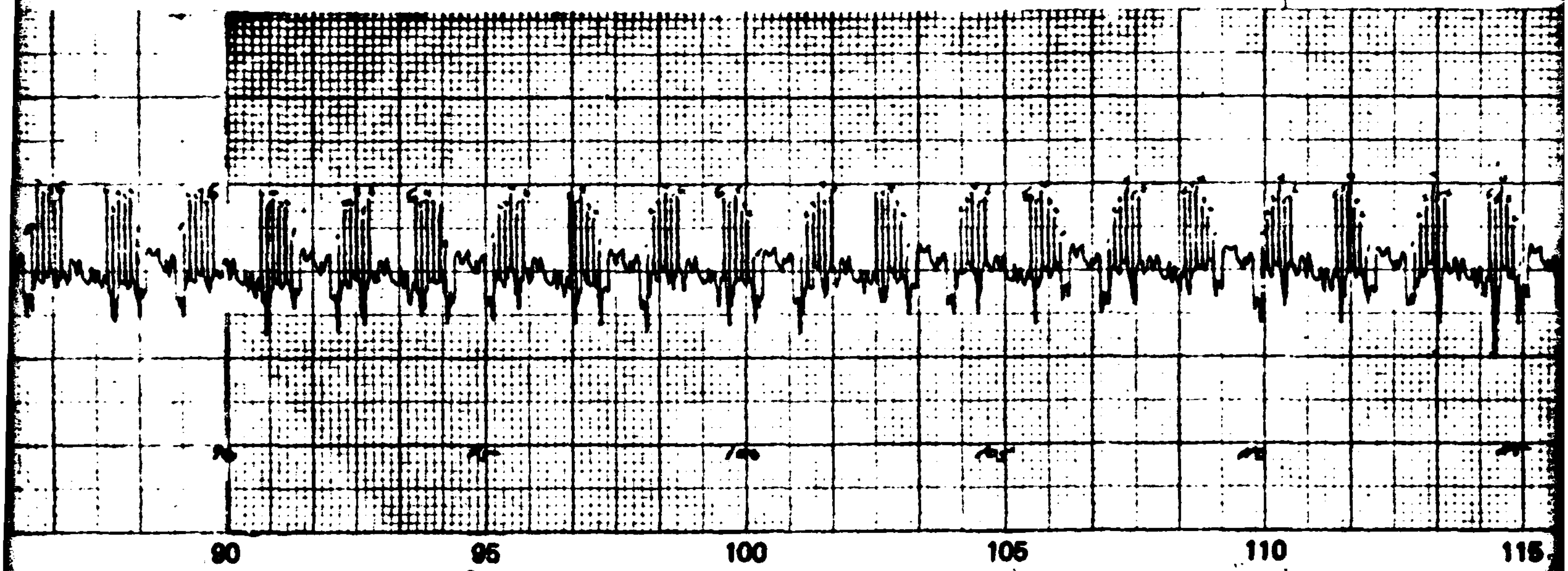
3

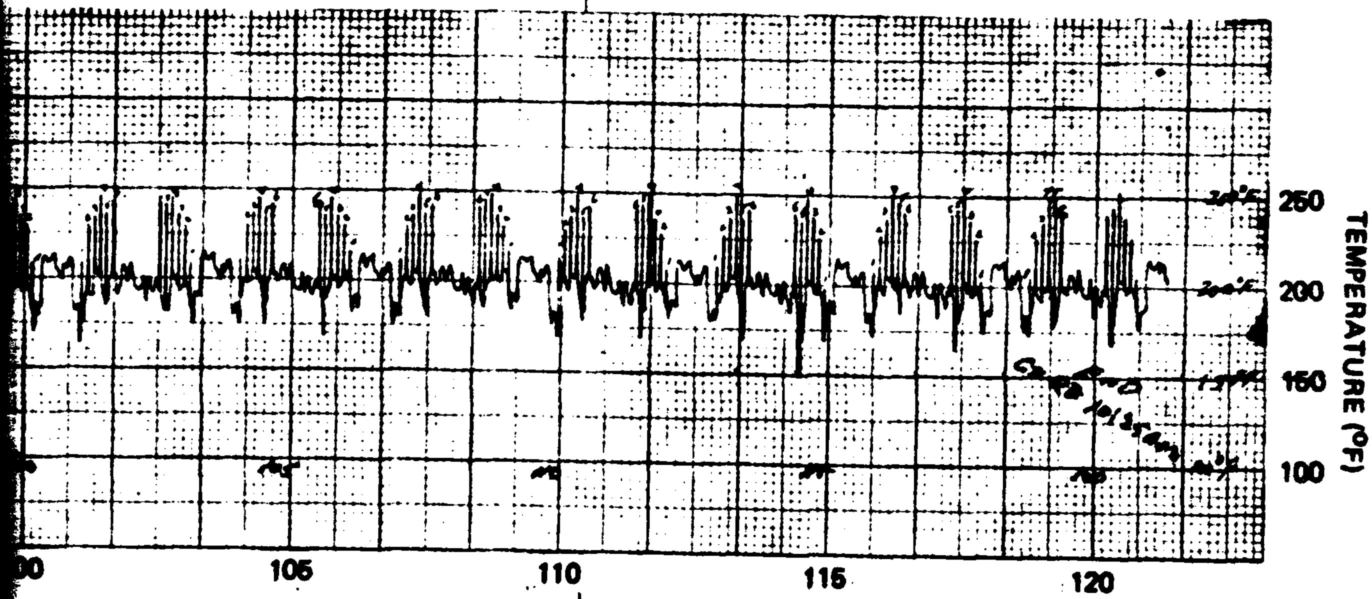
FILE





4


90
95
100
105
110
115



250
200
150
100
TEMPERATURE (°F)
105
110
115
120

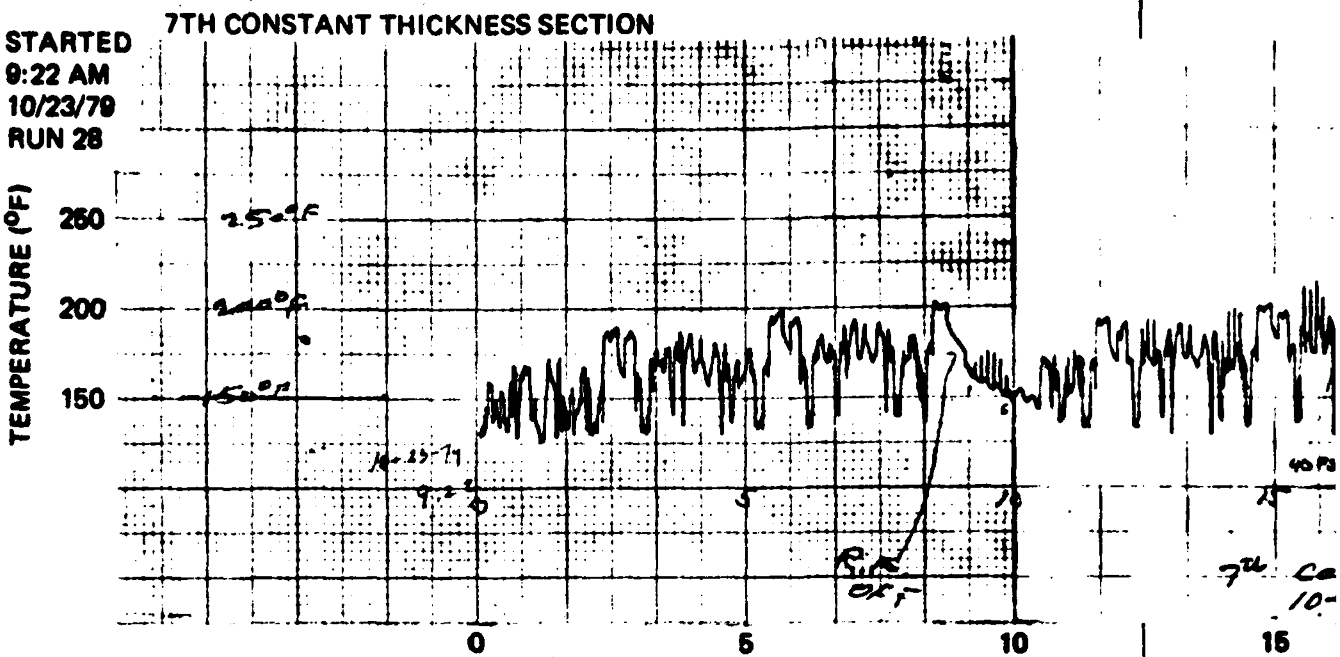


Figure E–15. Temperature Printout for 7th Constant Thickness Section (Run Number 28)

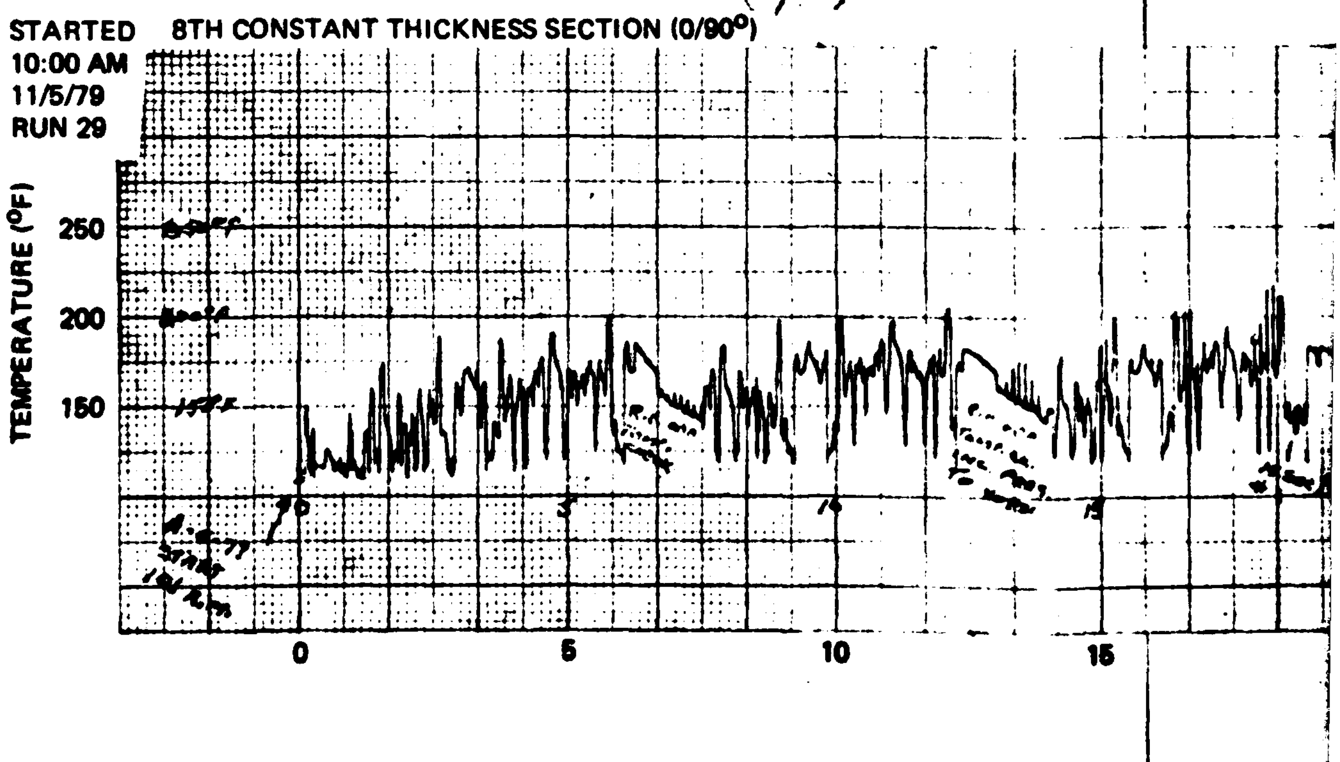
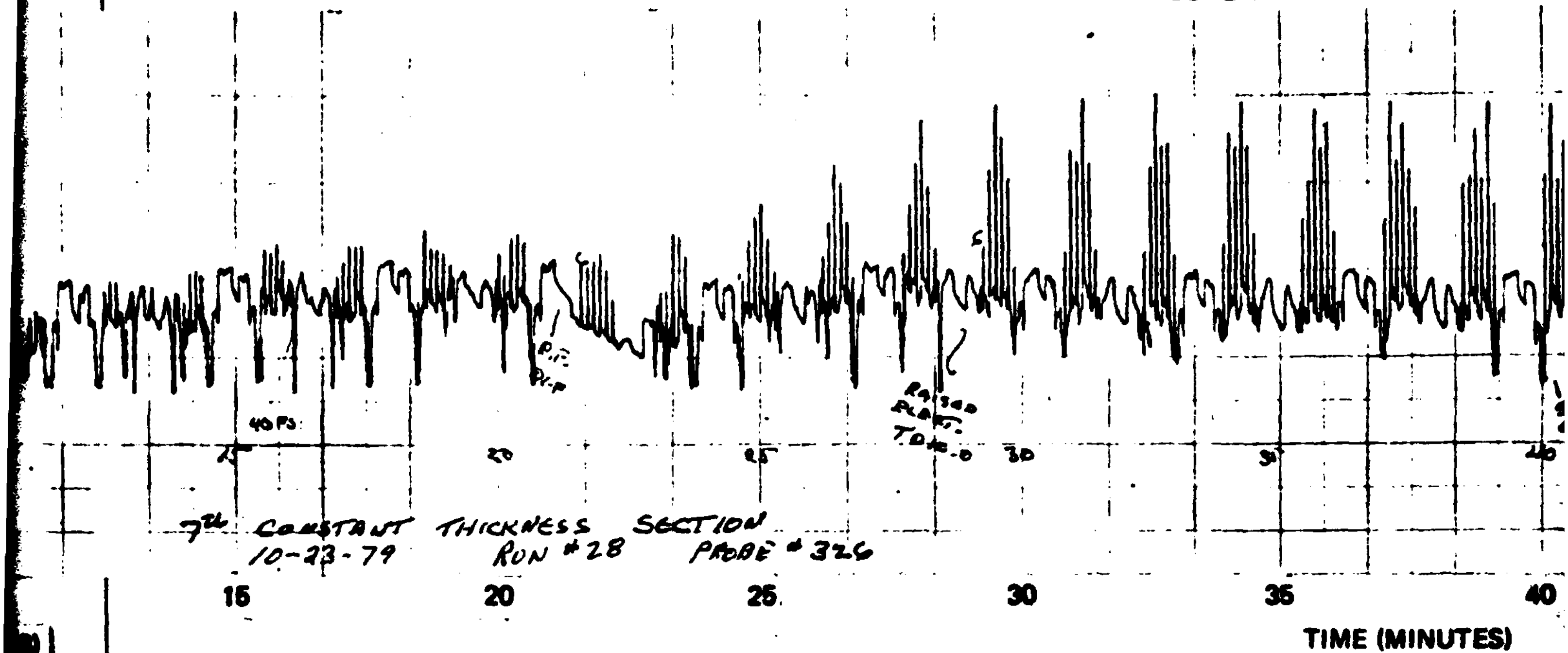
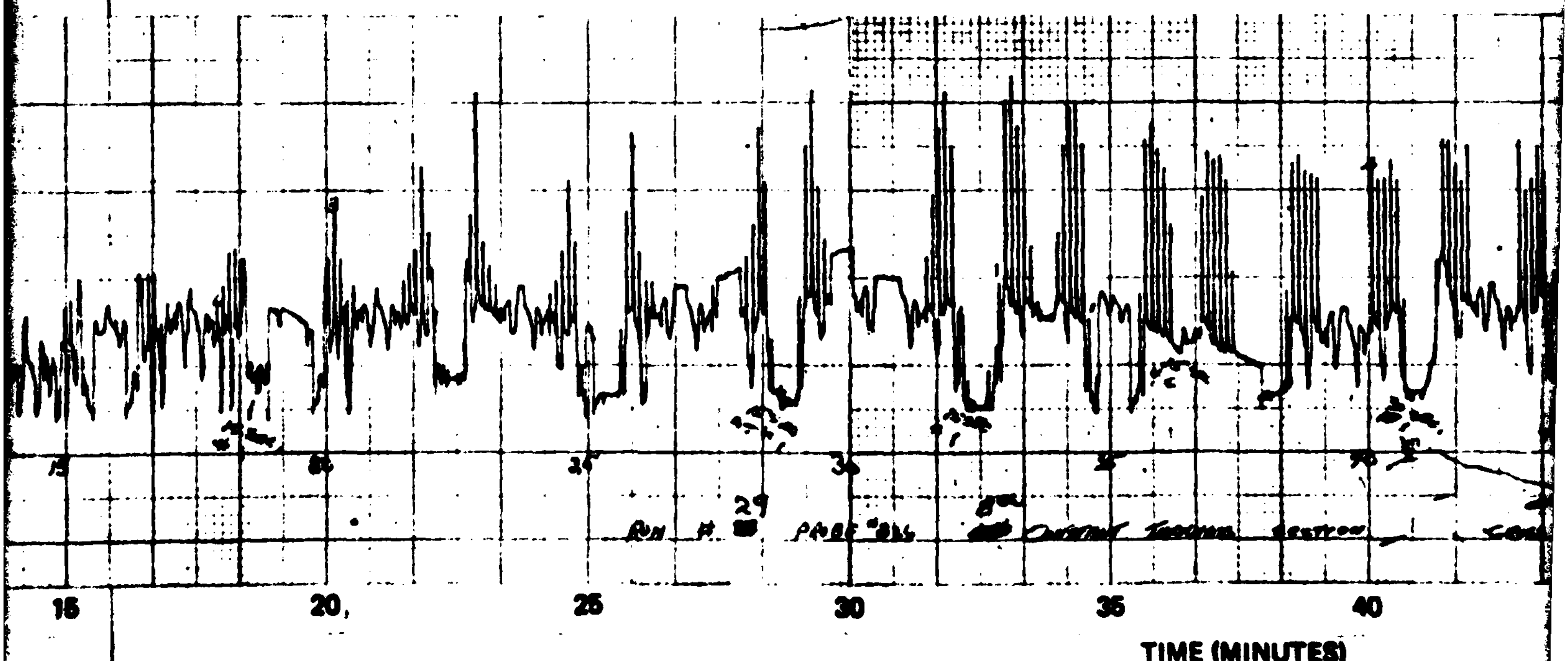


Figure E–16. Temperature Printout for 8th Constant Thickness Section (Run Number 29)

RF CURE TIME – TEMPERATURE P

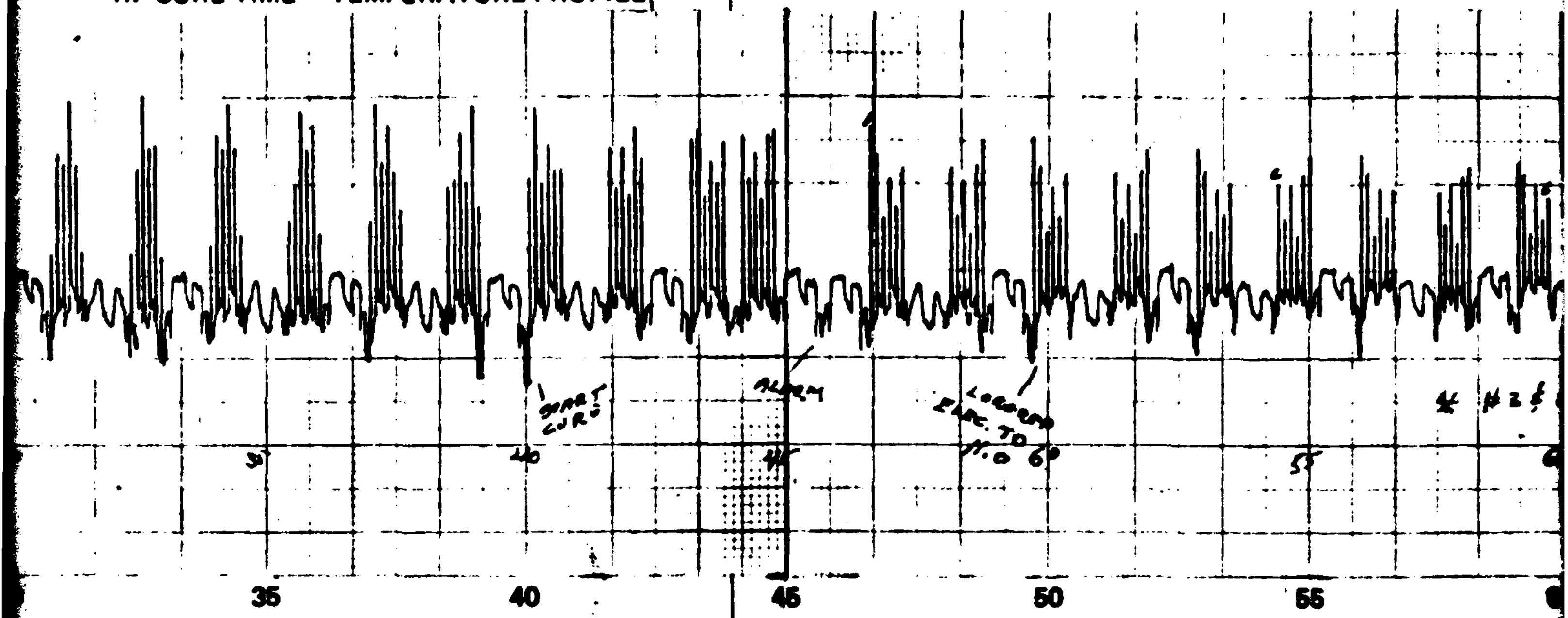




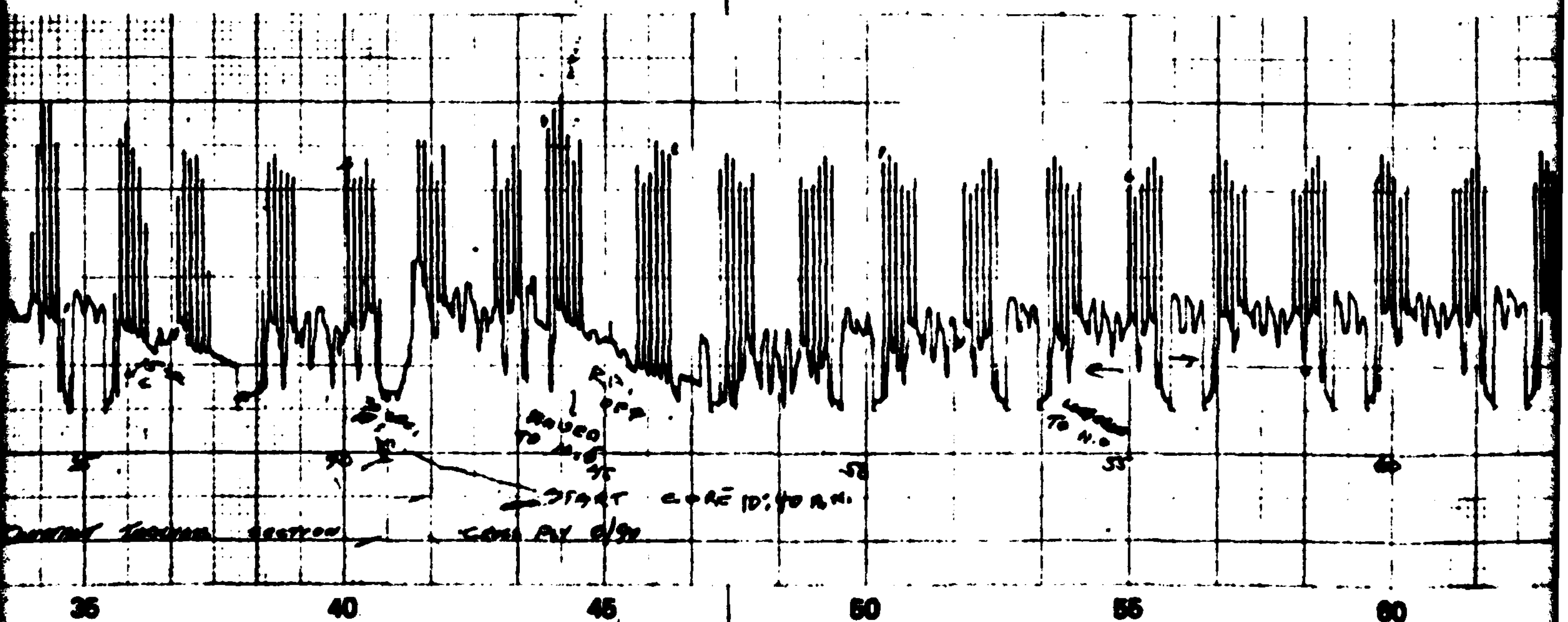
201

.7

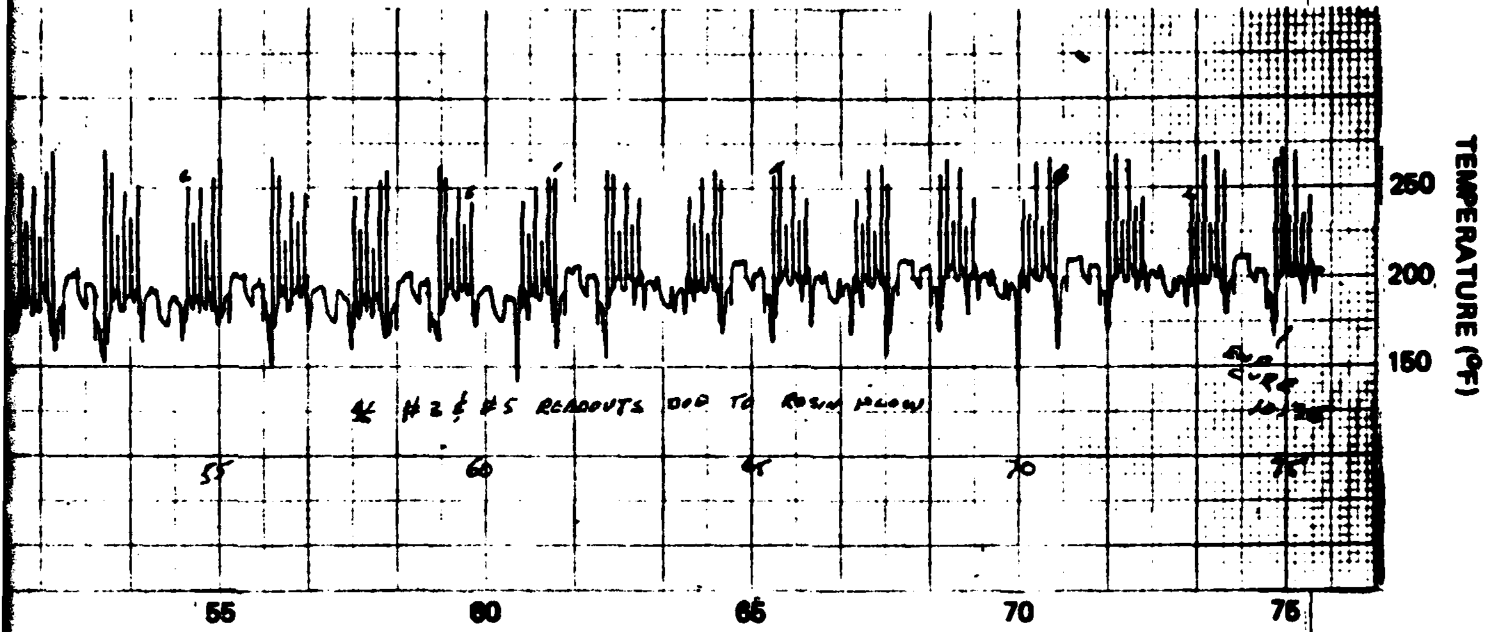
RF CURE TIME – TEMPERATURE PROFILE

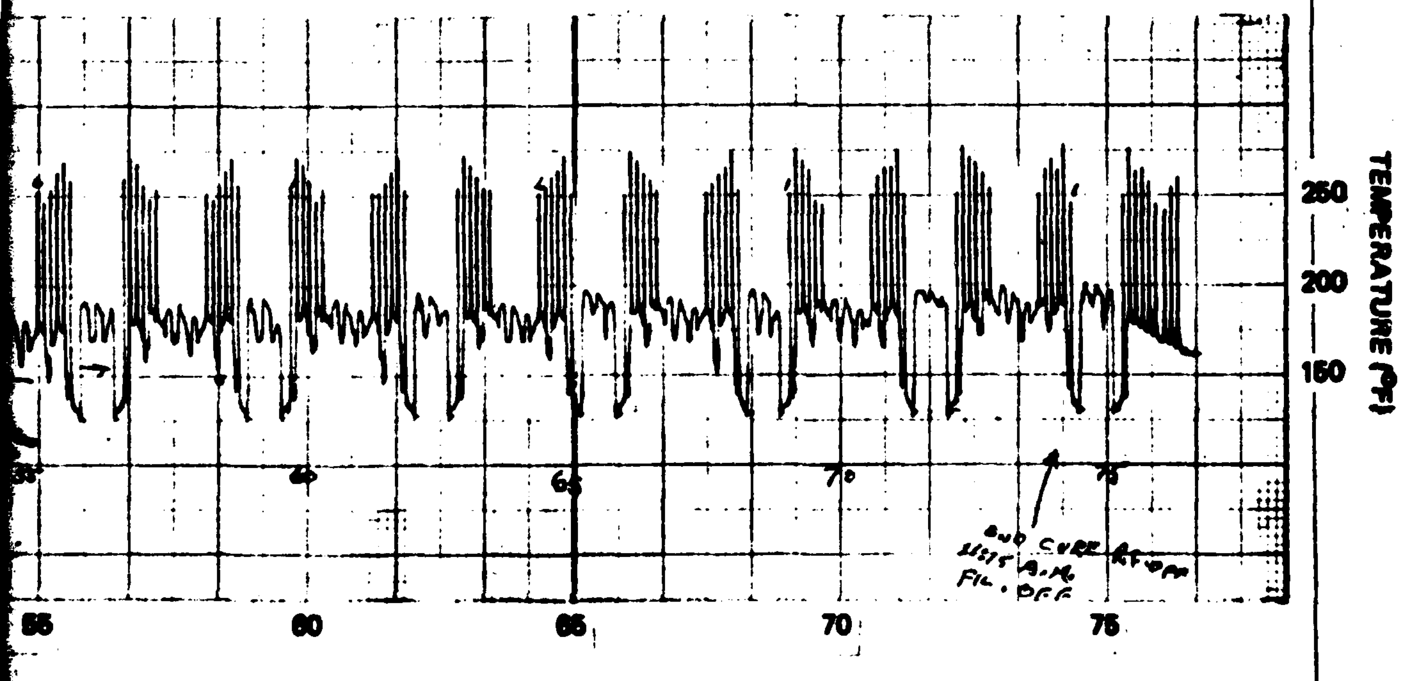


TIME (MINUTES)



TIME (MINUTES)


#2 & #5 READOUTS DUE TO ROSIN FLOW
TEMPERATURE (°F)
250
200
150
55
60
65
70
75


TEMPERATURE (°F)
250
200
150
55
60
65
70
75

STARTED
8:00 AM
11/2/79
RUN 30

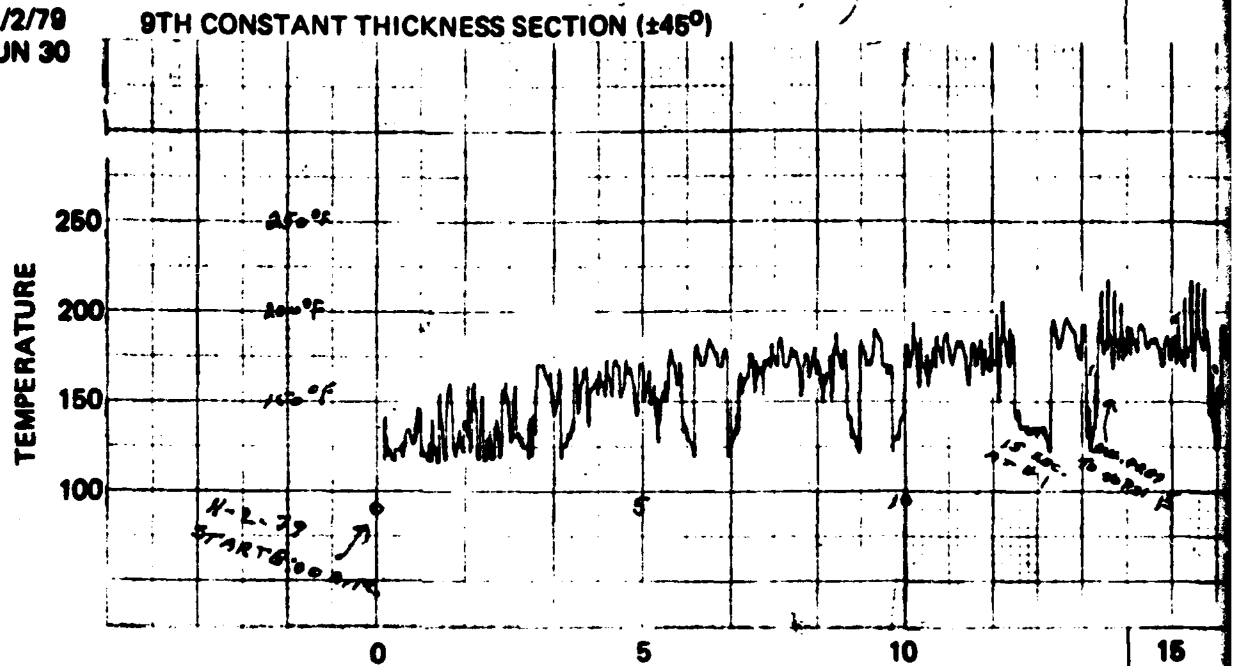


Figure E–17. Temperature Printout for 9th Constant Thickness Section (±45°) (Run Number 30)

11/7/79
RUN 31

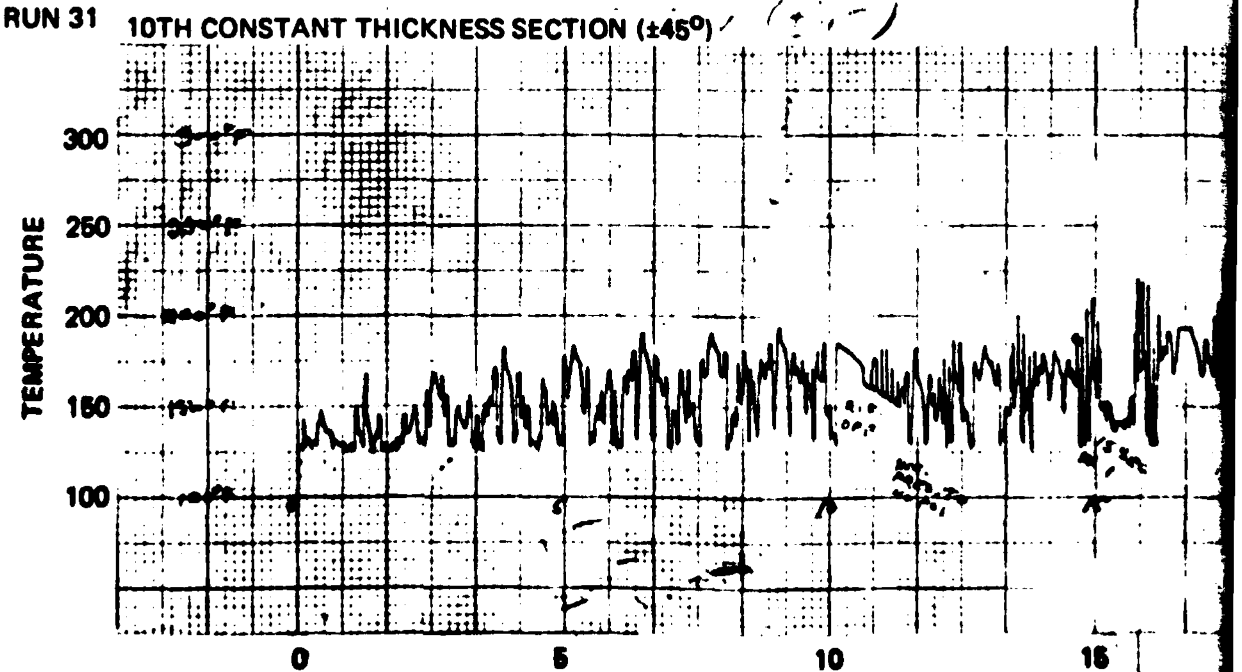
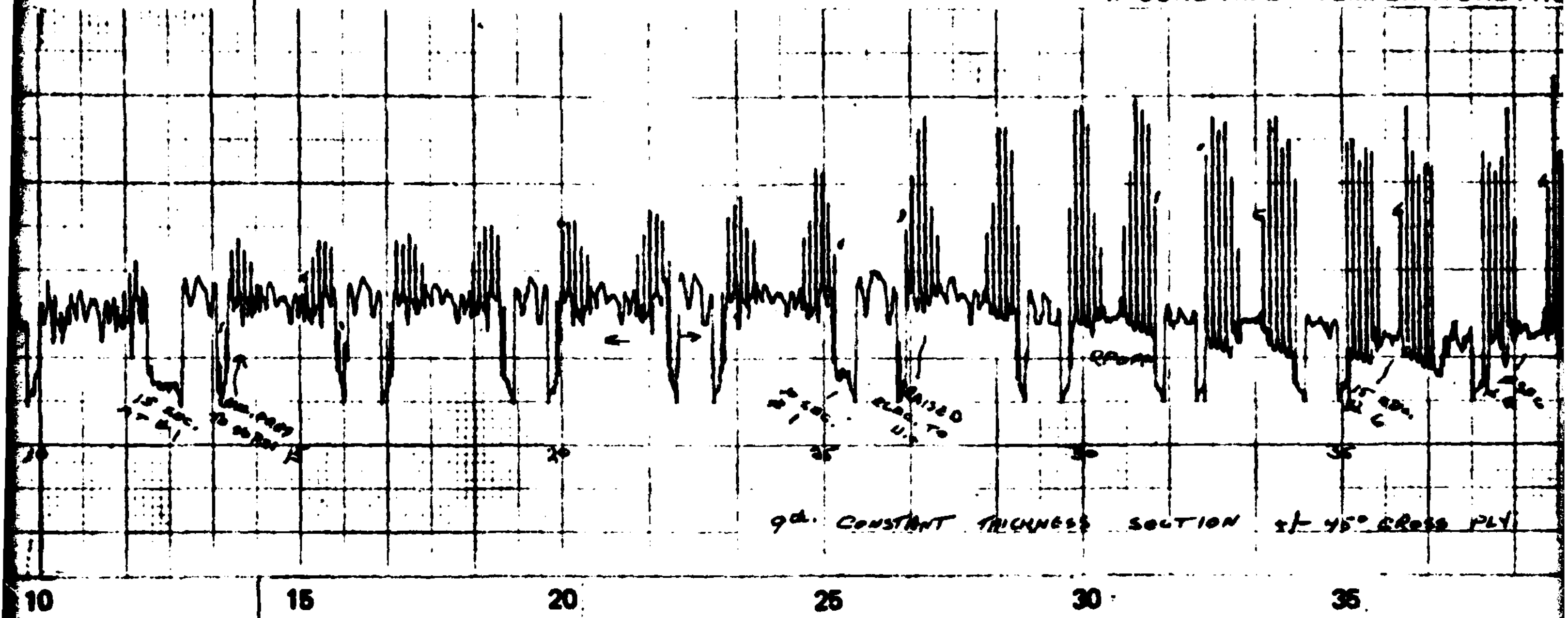
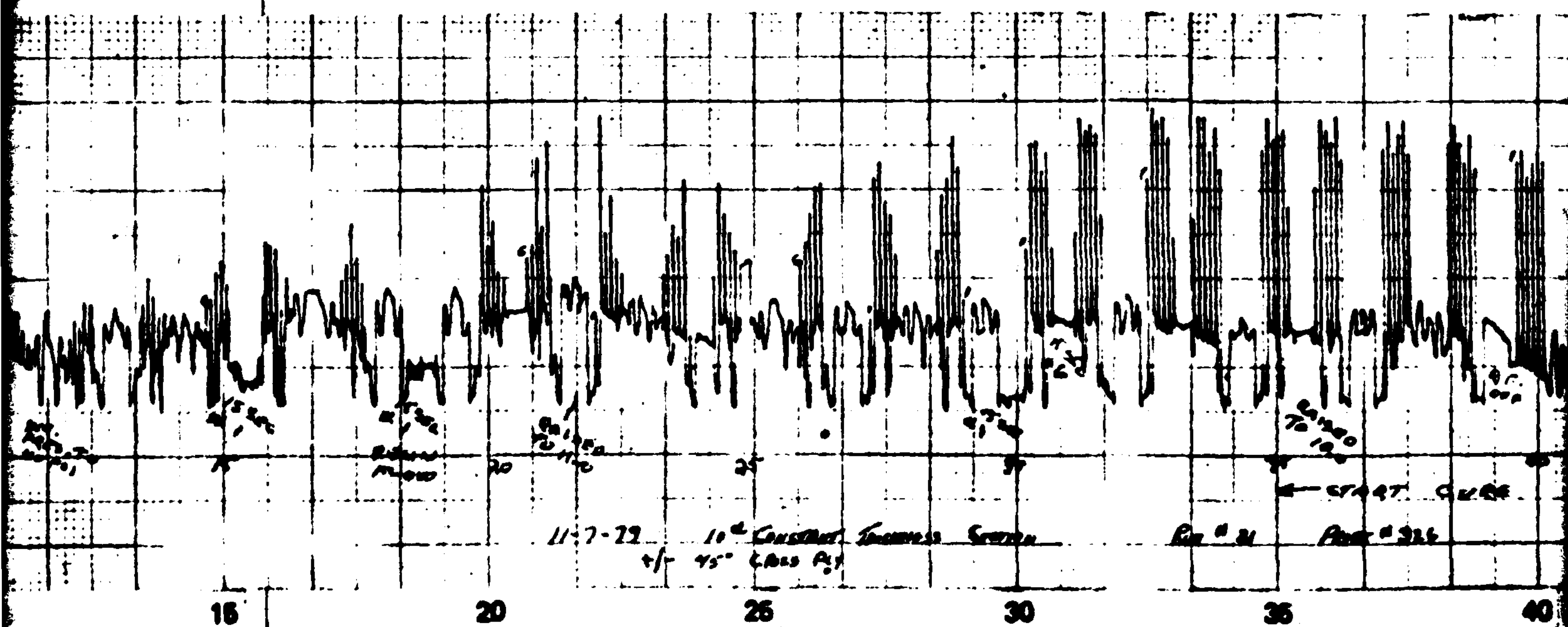


Figure E–18. Temperature Printout for 10th Constant Thickness Section (±45°) (Run Number 31)

RF CURE TIME – TEMPERATURE PRO

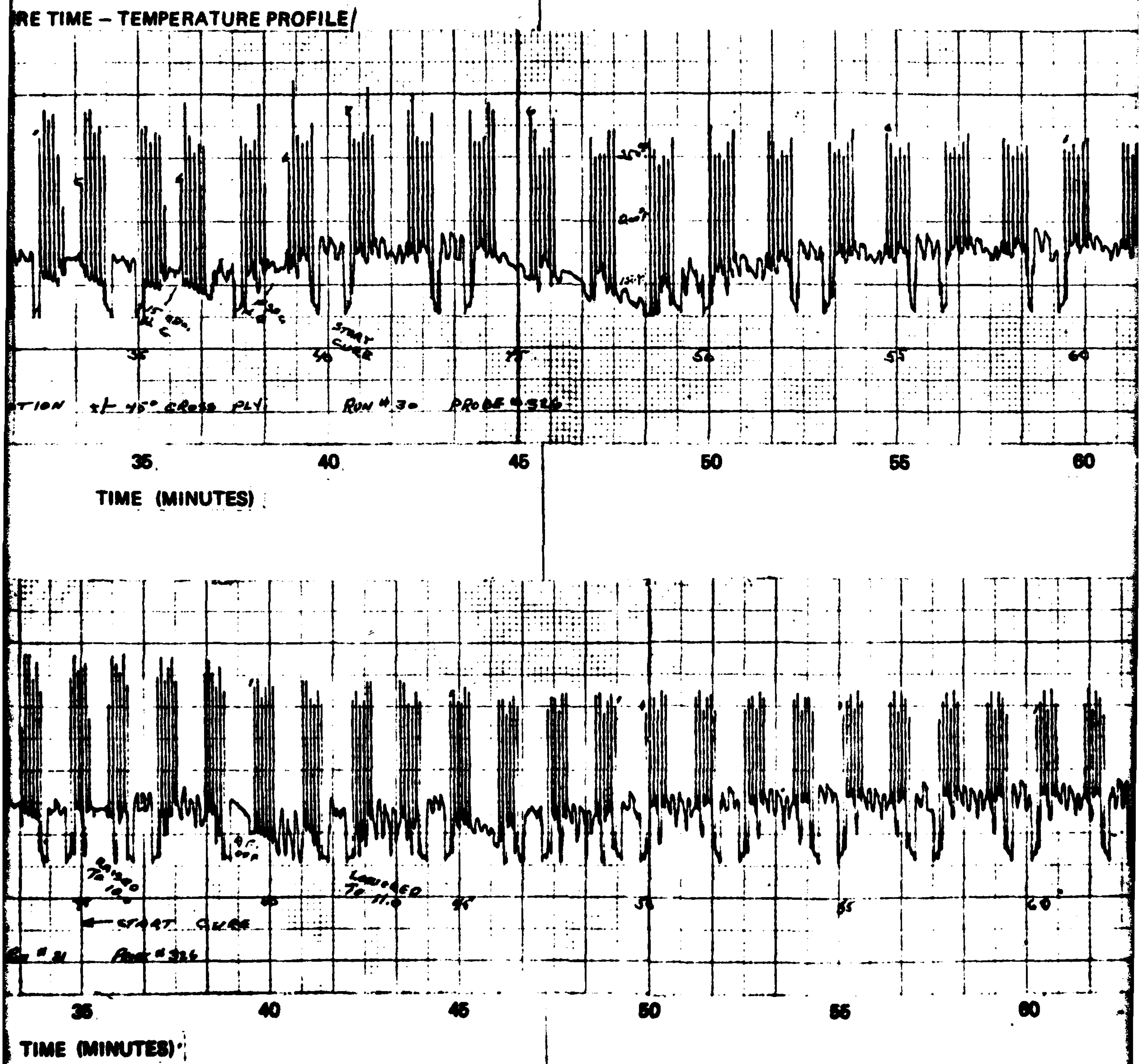


(Run Number 30)

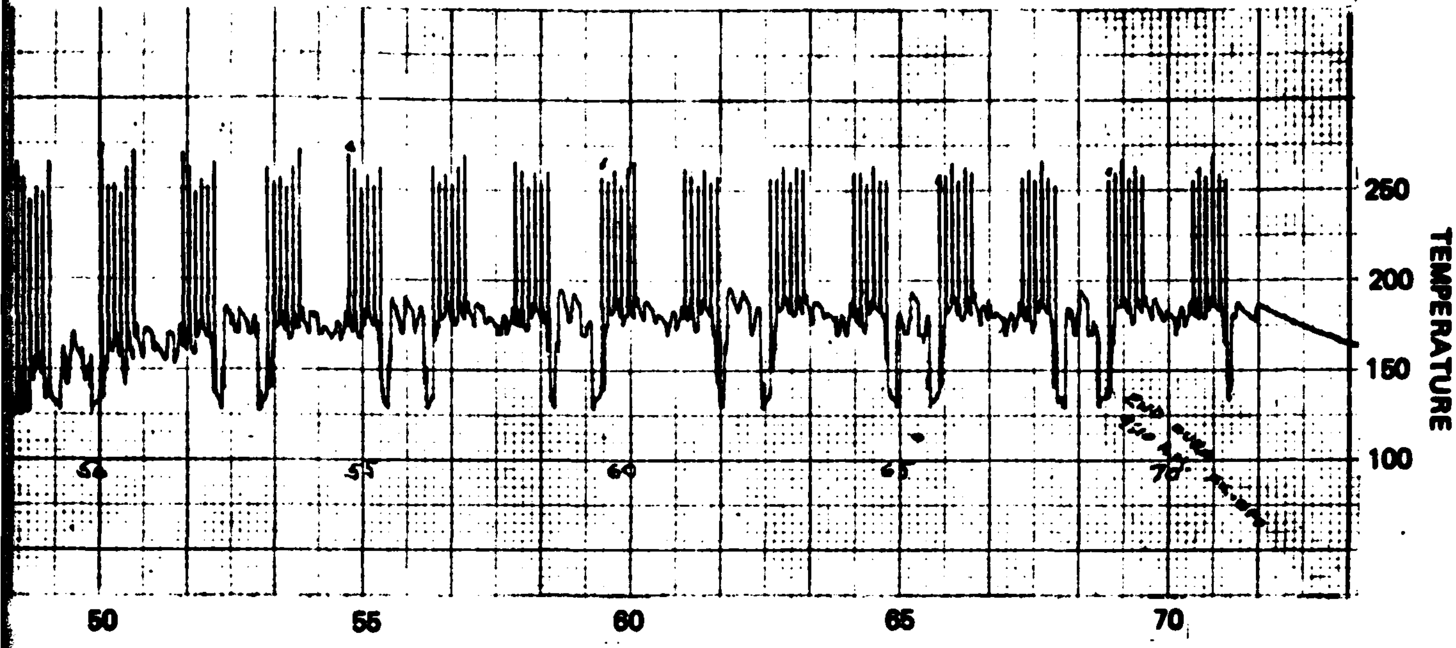


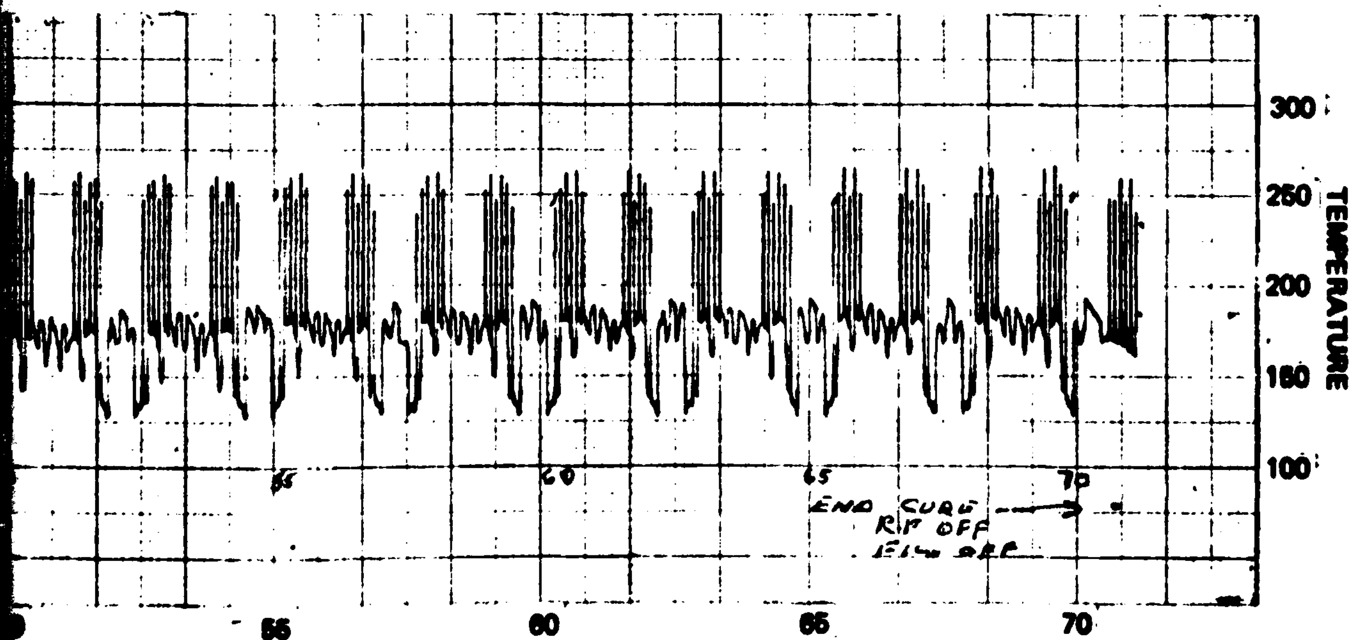
(Run Number 31)

2


RE TIME – TEMPERATURE PROFILE
35
40
45
50
55
60
TIME (MINUTES)
START CURE
35
40
45
50
55
60
TIME (MINUTES)

3


250
200
150
100
TEMPERATURE
50
55
60
65
70


300
250
200
150
100
TEMPERATURE
END CURE
55
60
65
70

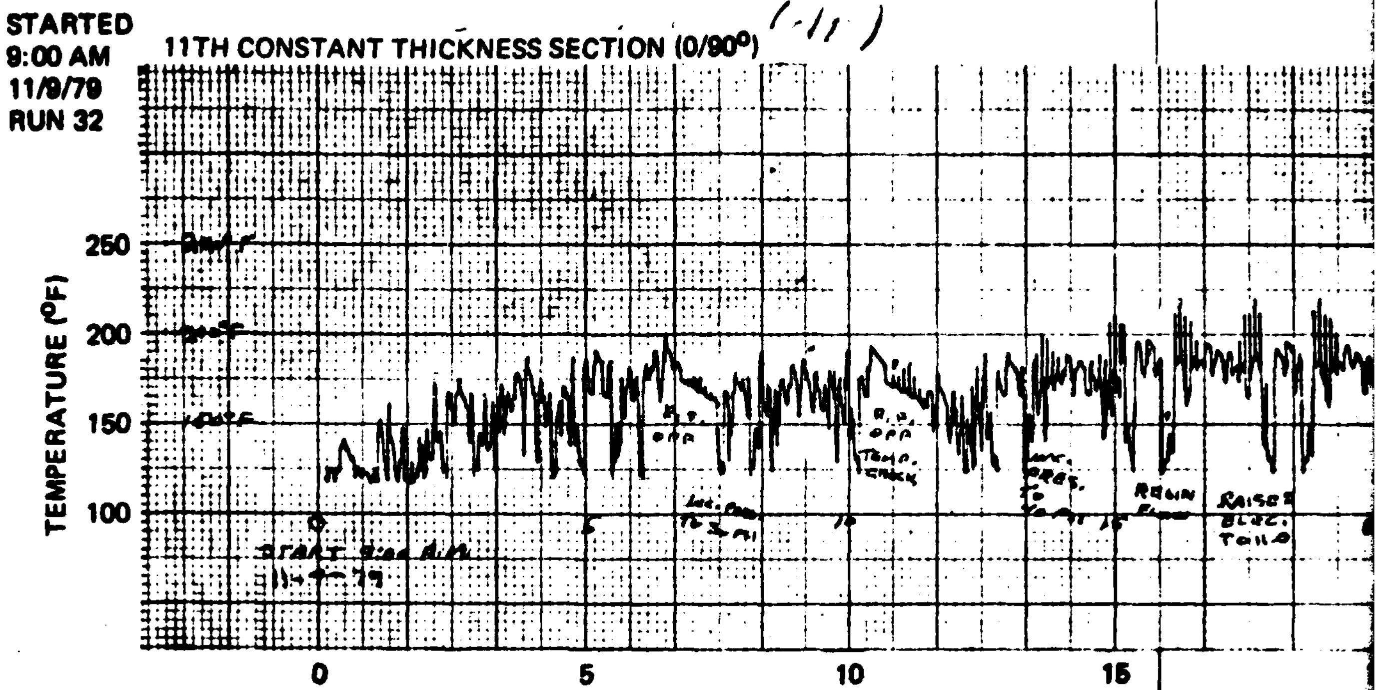


Figure E–19. Temperature Printout for 11th Constant Thickness Section (0/90°) (Run Number 32)

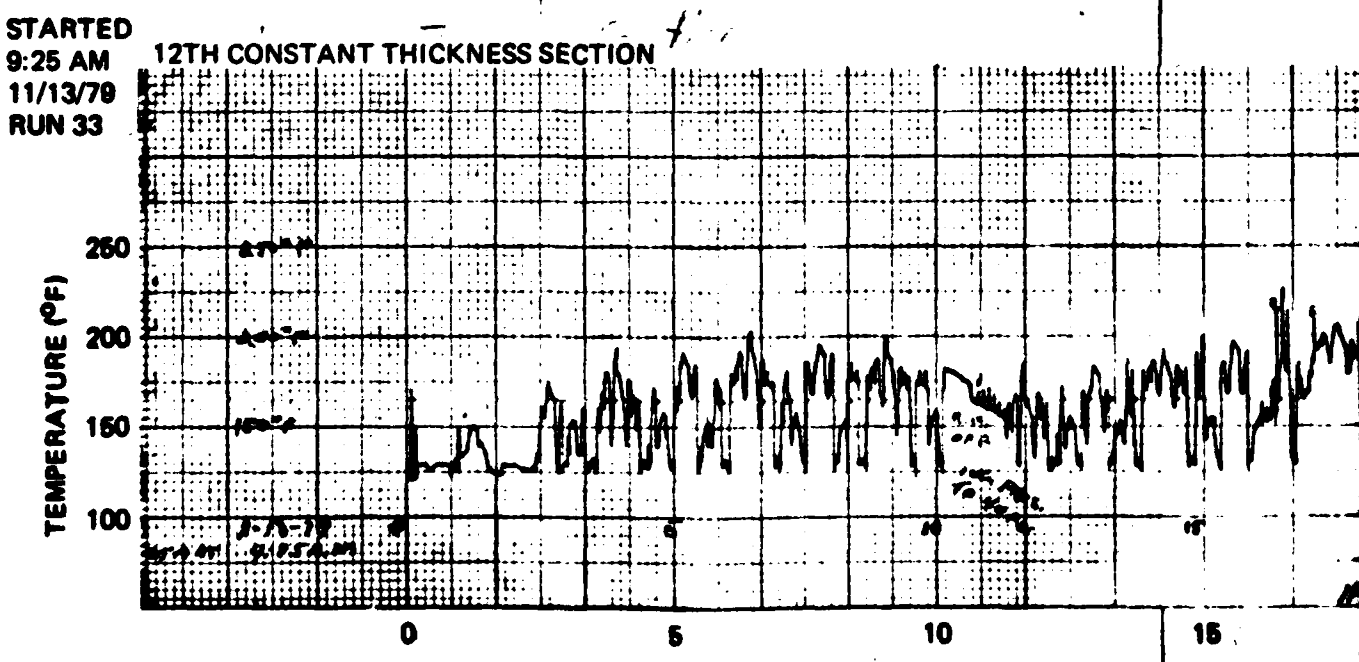
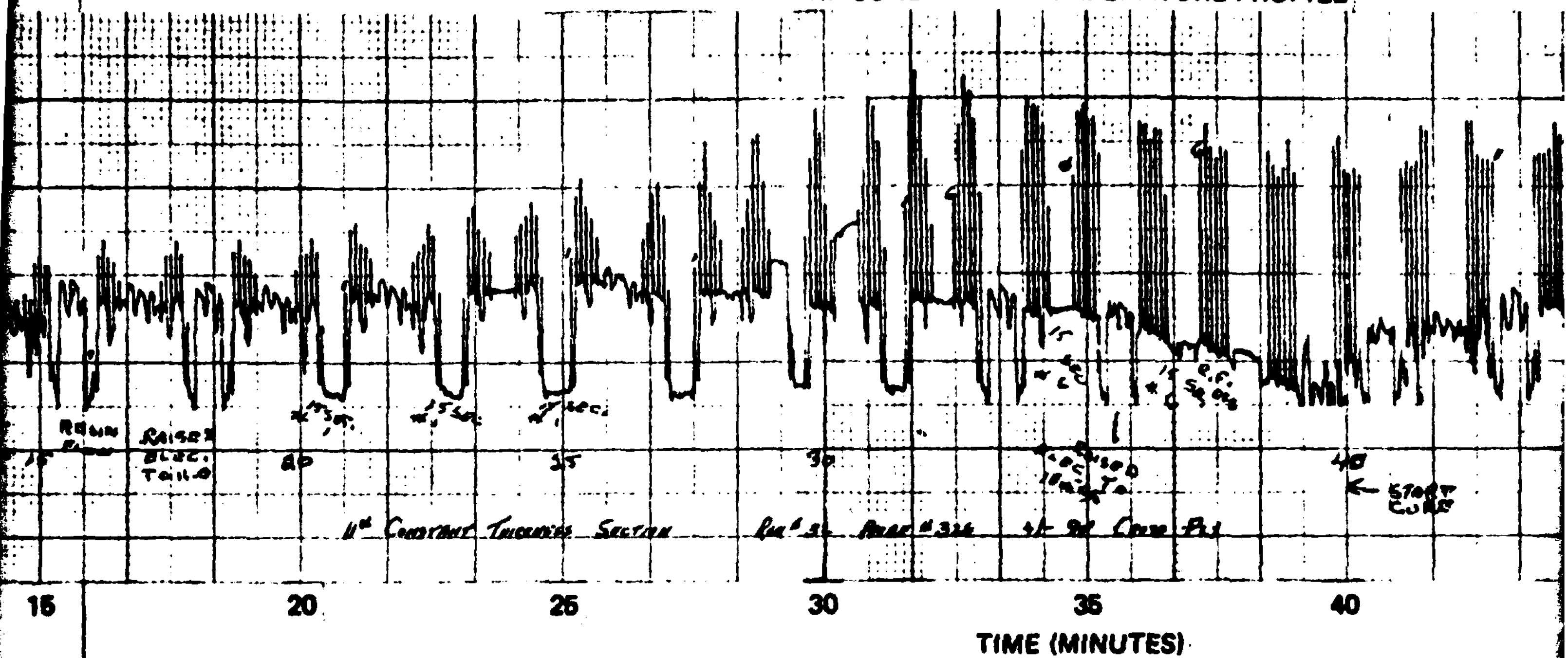
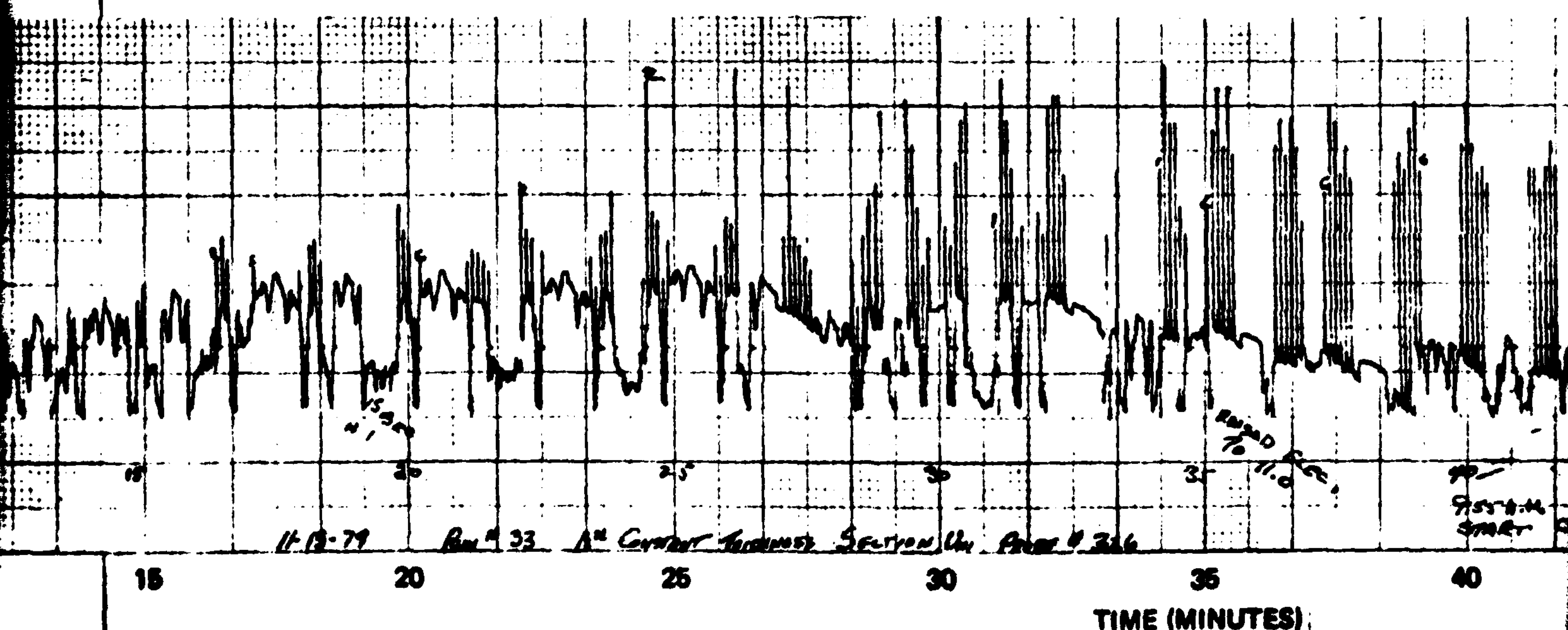


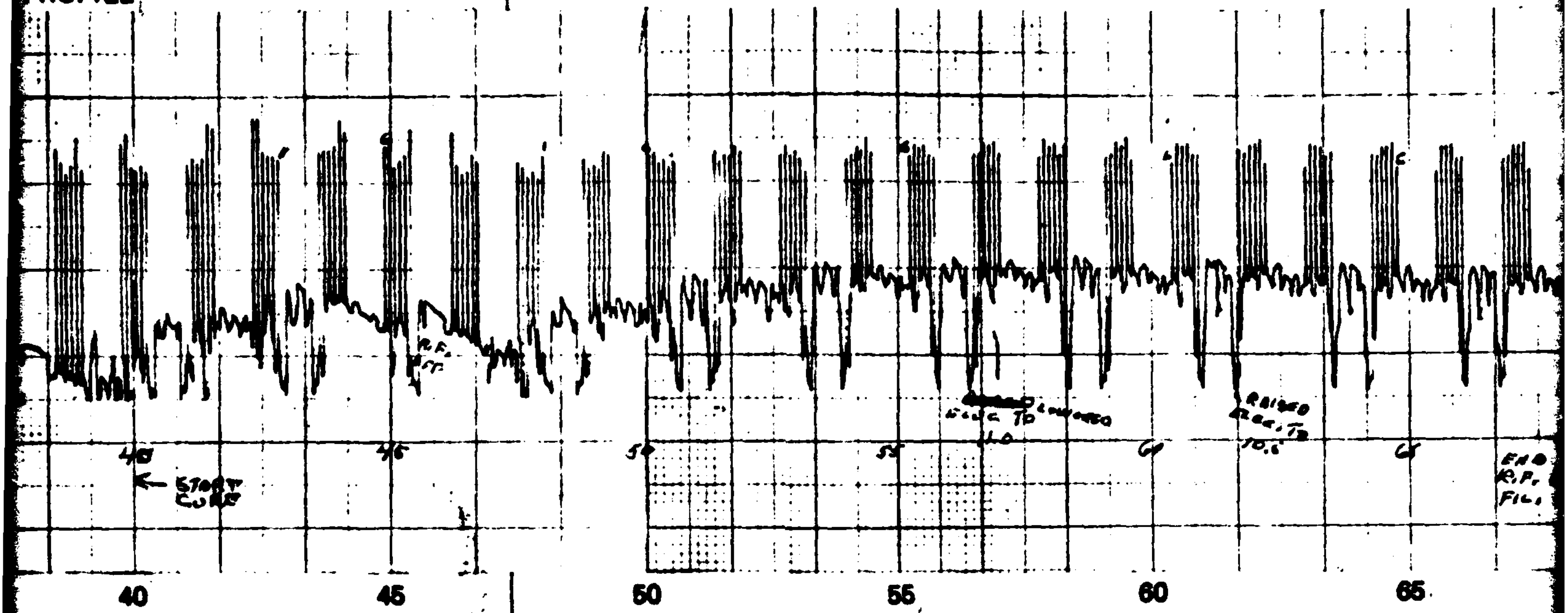
Figure E–20. Temperature Printout for 12th Constant Thickness Section (Run Number 33)

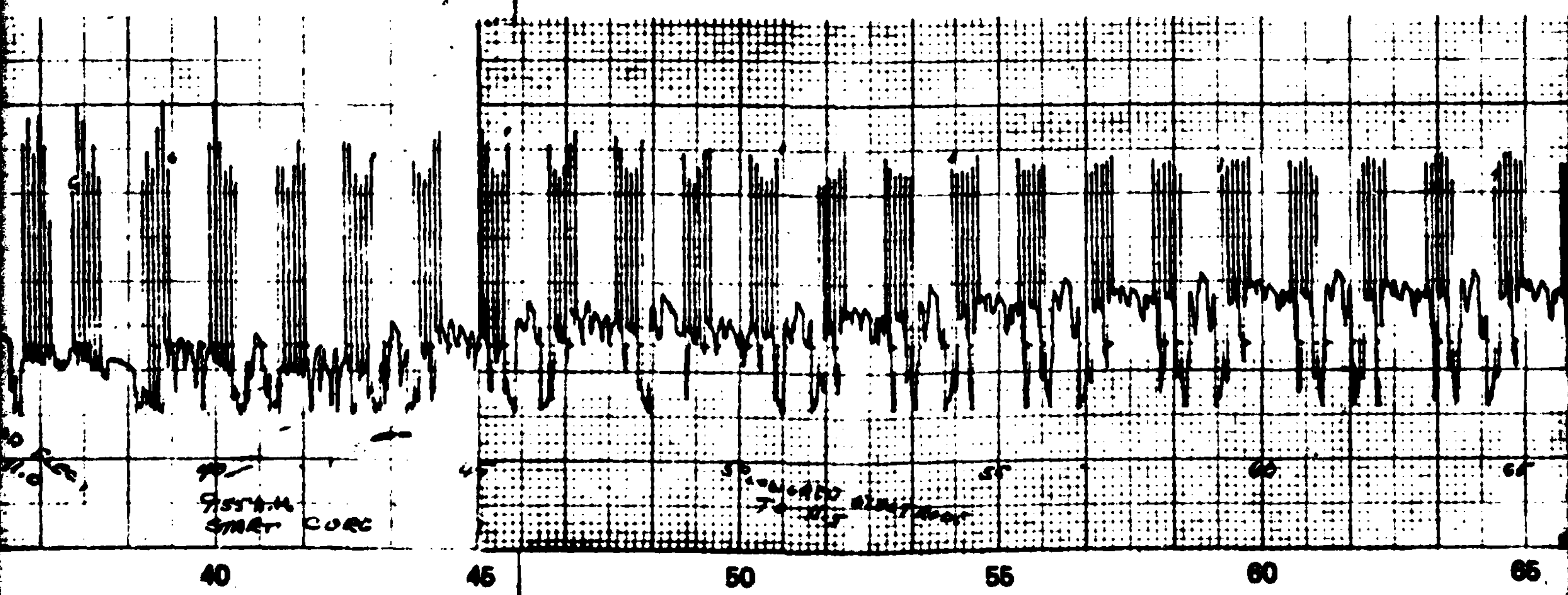
RF CURE TIME – TEMPERATURE PROFILE





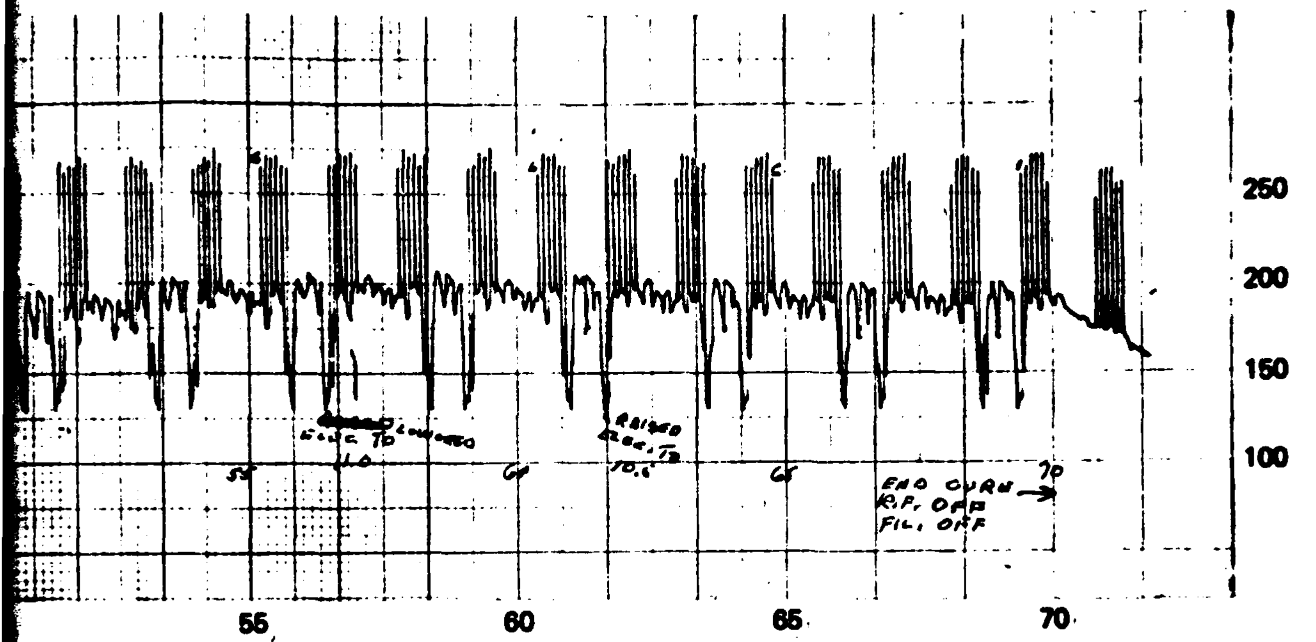
PROFILE

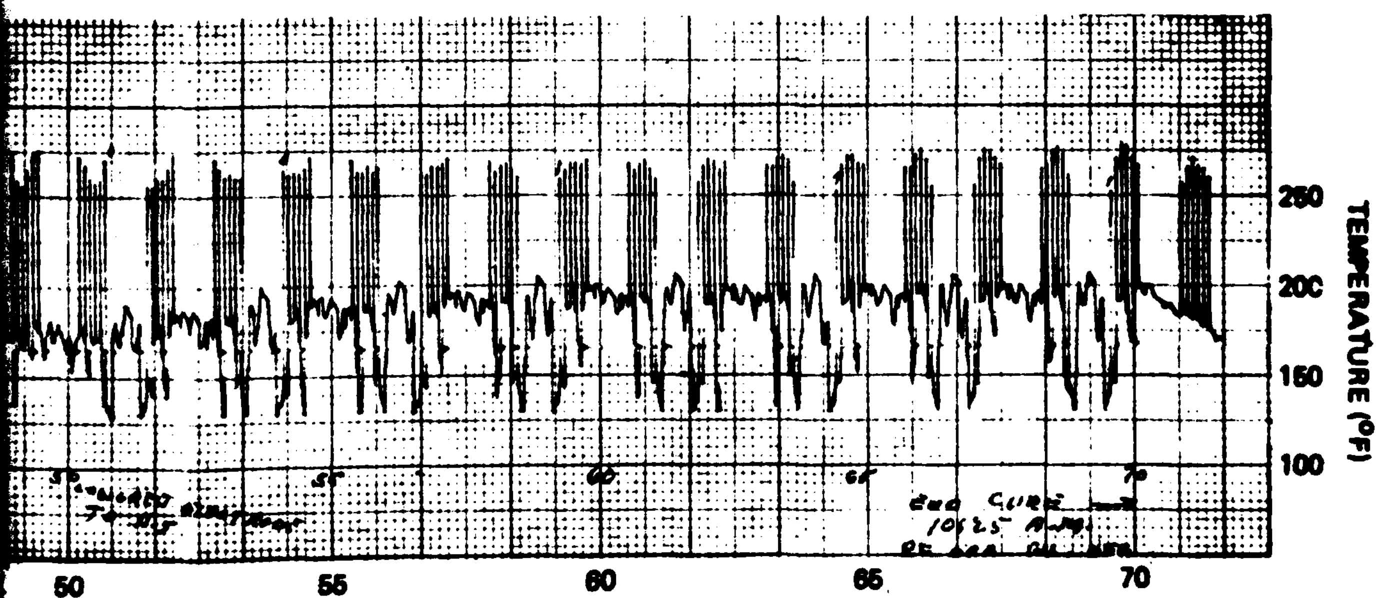




TES)

3


TEMPERATURE (°F)
250
200
150
100
55
60
65
70
END CURE
R.F. OFF
FIL. OFF


TEMPERATURE (°F)
250
200
150
100
50
55
60
65
70
END CURE

STARTED
9:20 AM
11/16/79
RUN 34 9TH WEDGE SECTION

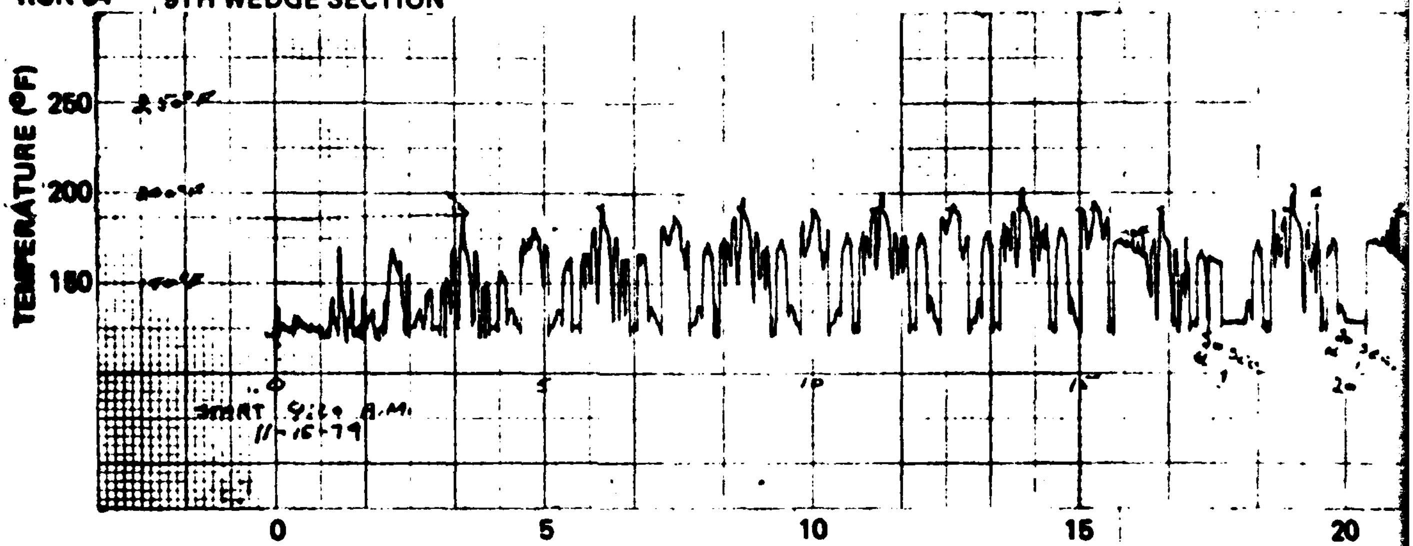


Figure E–21. Temperature Printout for 9th Wedge Section (Run Number 34)

STARTED
12:36 AM
11/21/79
RUN 35 13TH CONSTANT THICKNESS SECTION

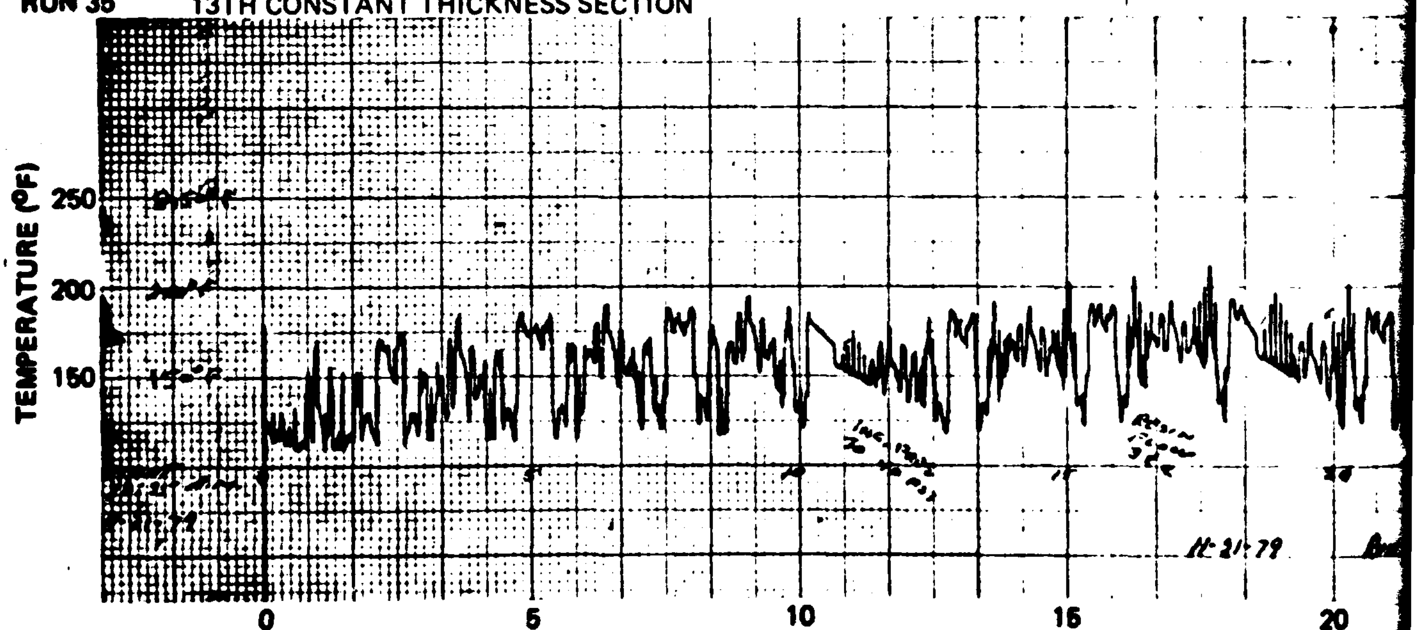
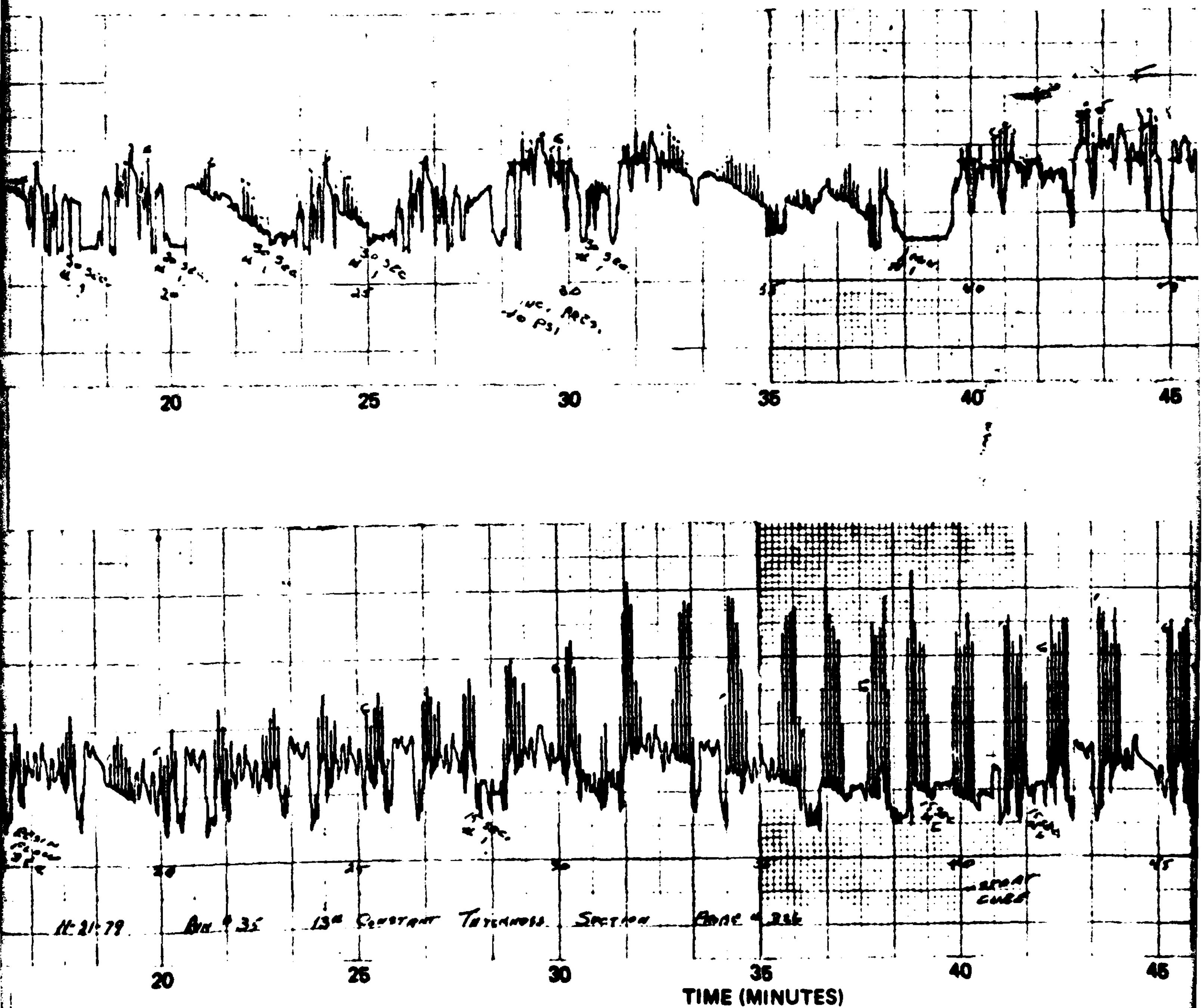
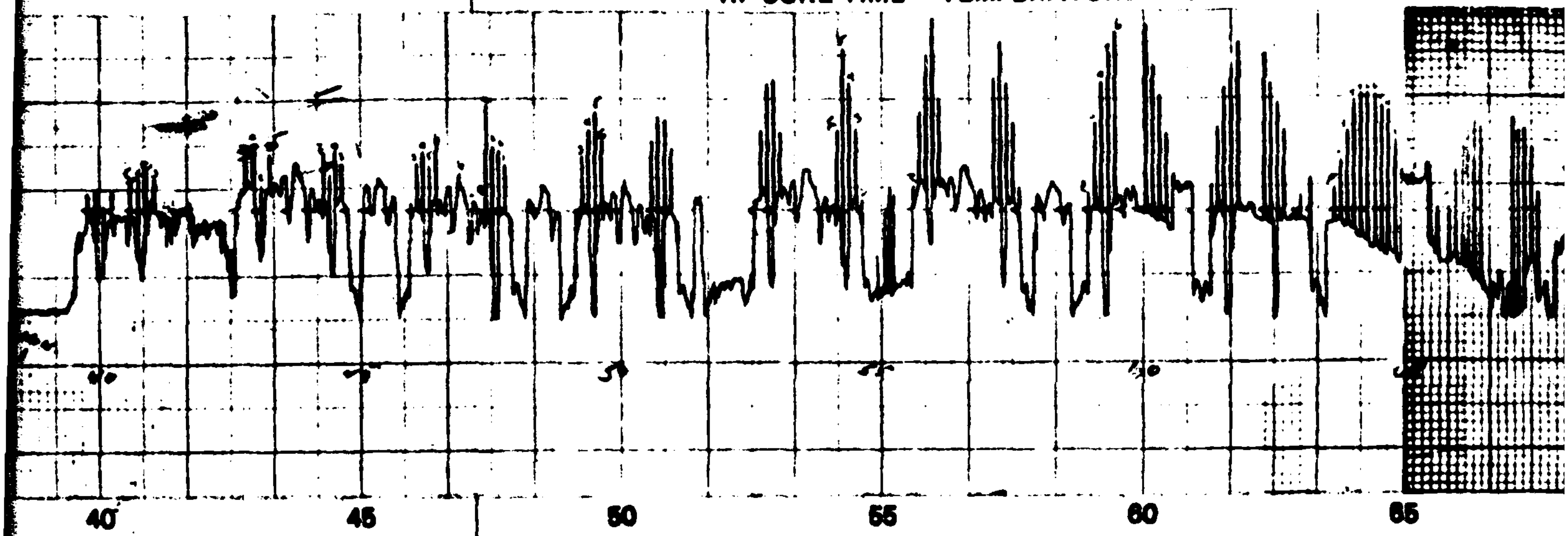
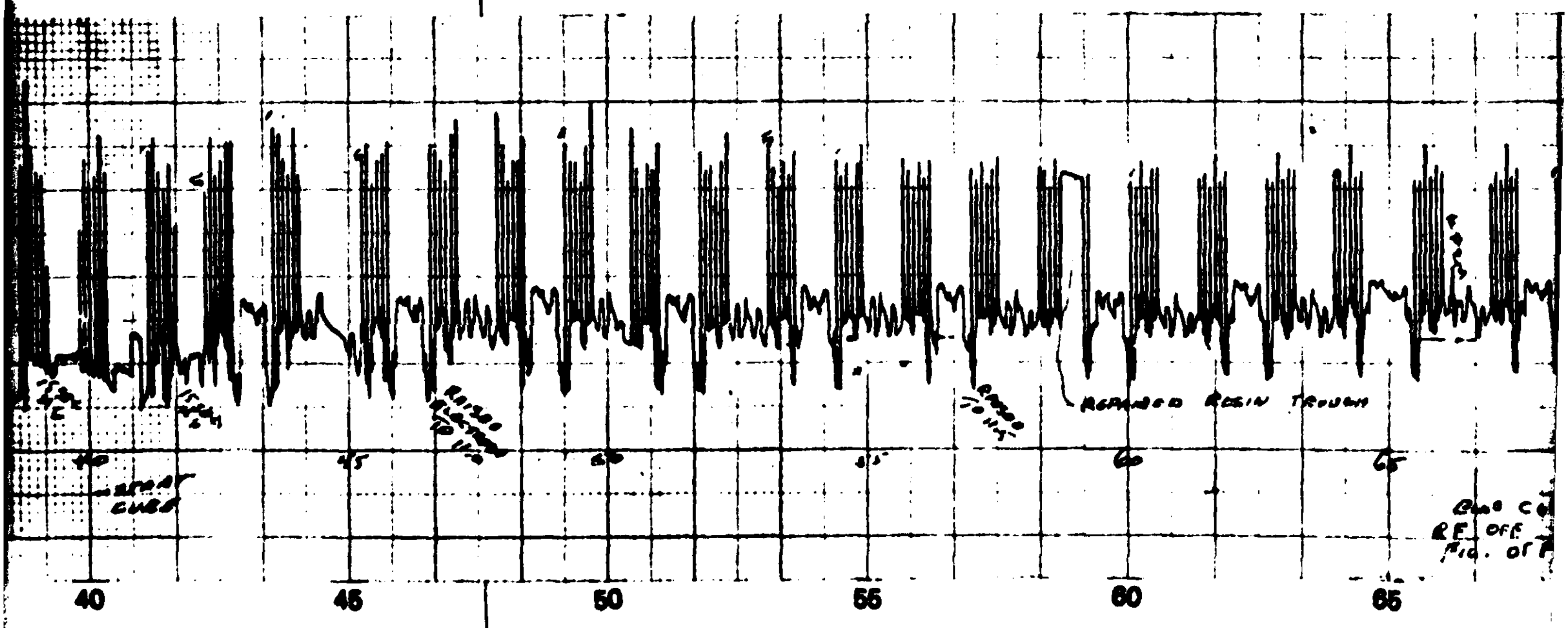


Figure E–22. Temperature Printout for 13th Constant Thickness Section (Run Number 35)

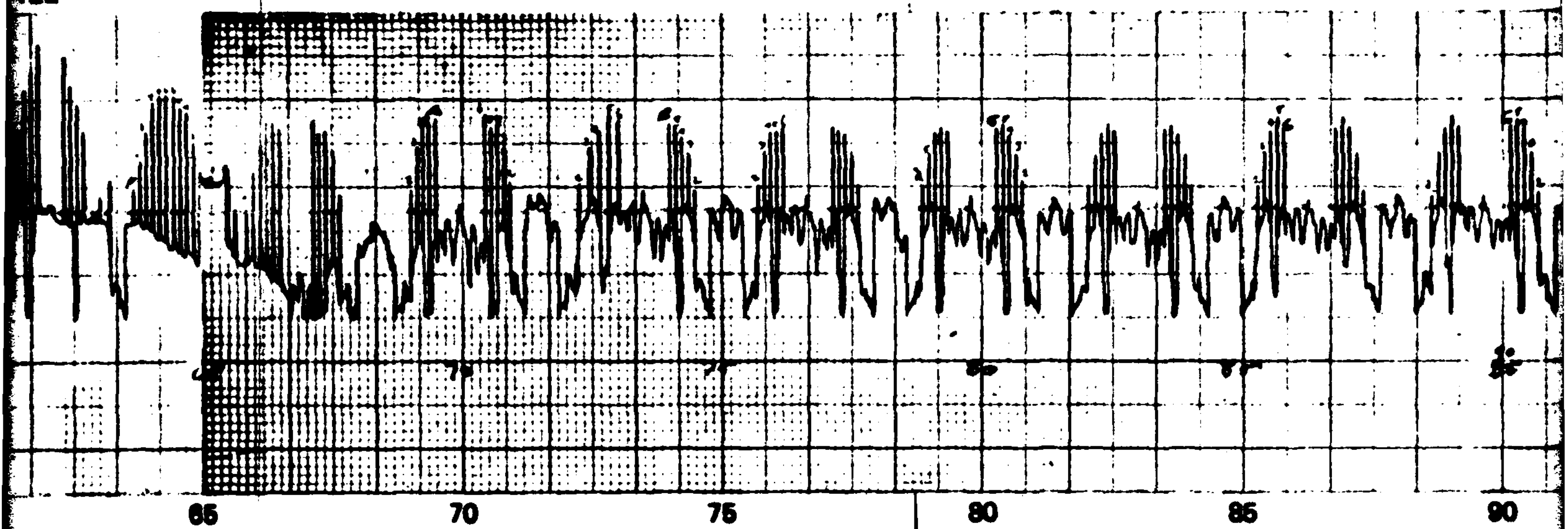

20
25
30
35
40
45
20
25
30
35
40
45
TIME (MINUTES)

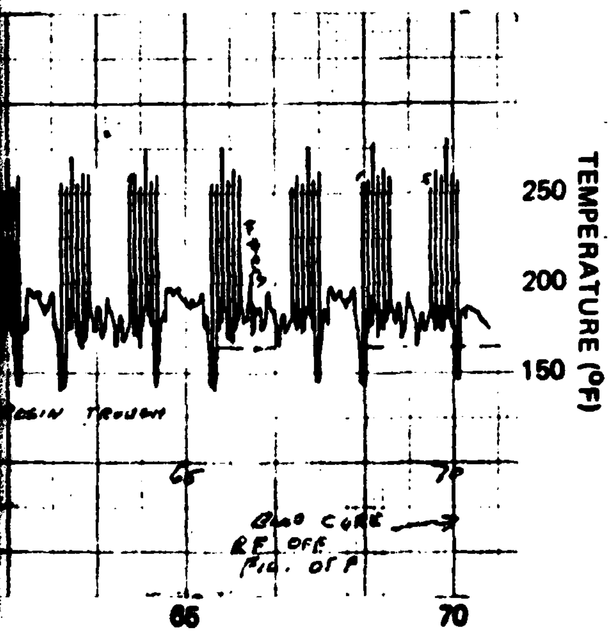
RF CURE TIME – TEMPERATURE PROFILE

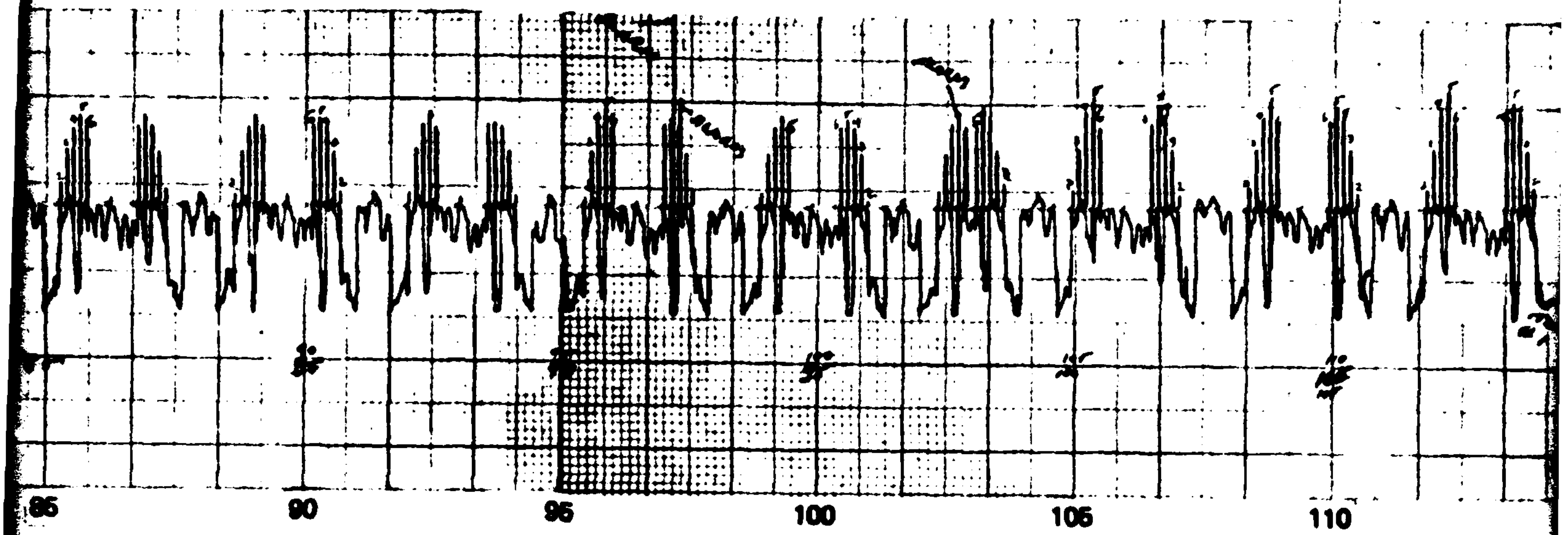


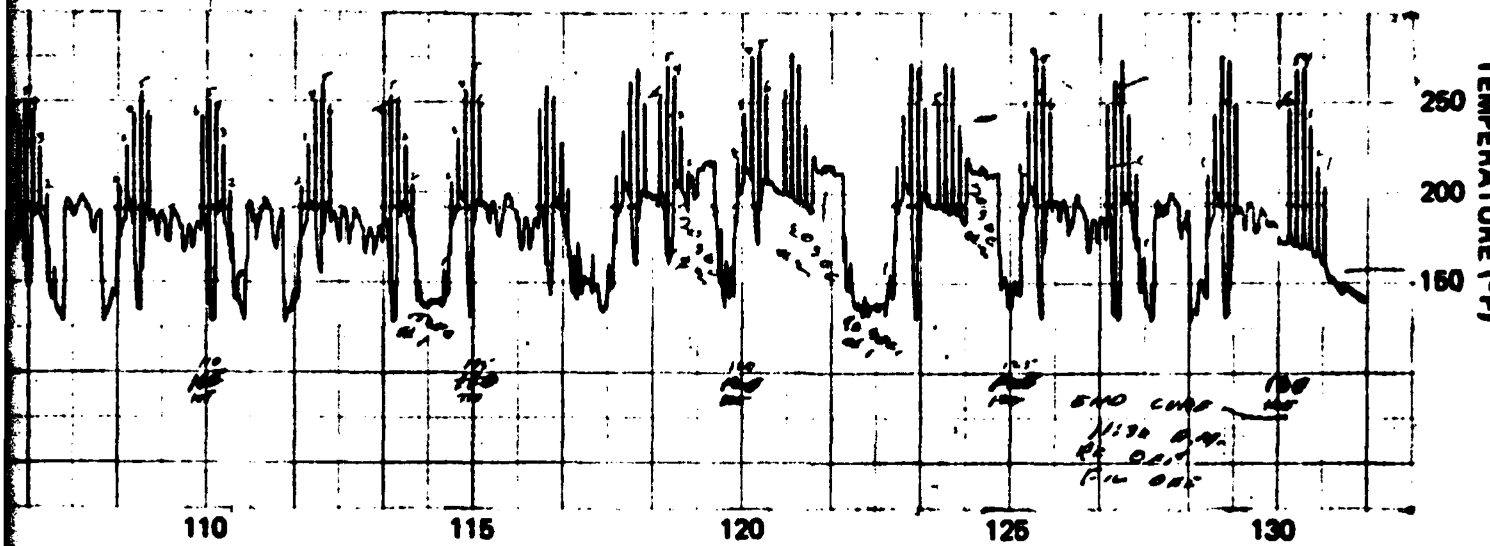


ILE






85
90
95
100
105
110



TEMPERATURE (°F)
250
200
150
110
115
120
125
130

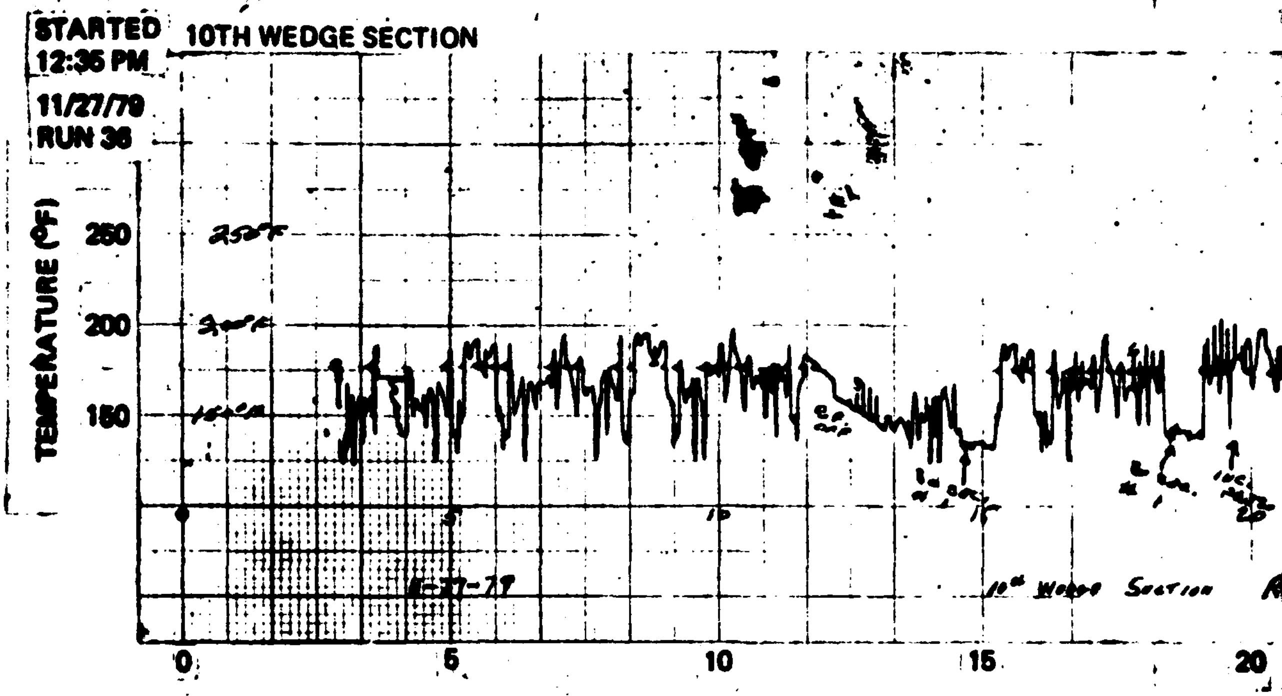


Figure E–23. Temperature Printout for 10th Wedge Section (Run Number 36)

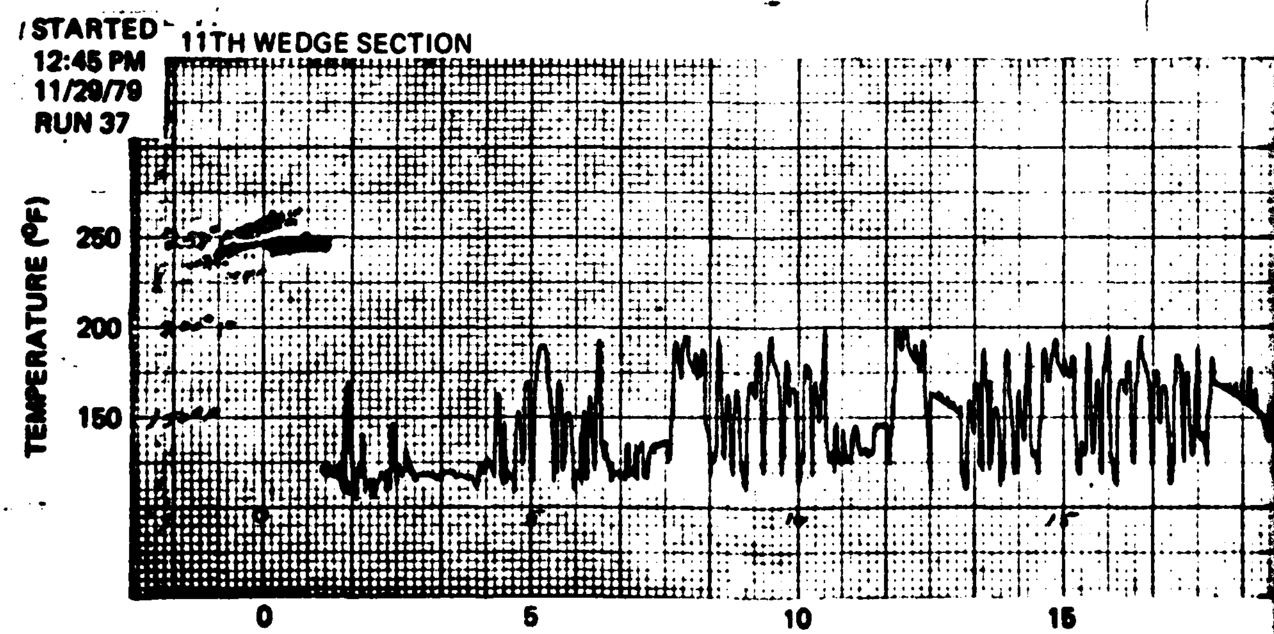
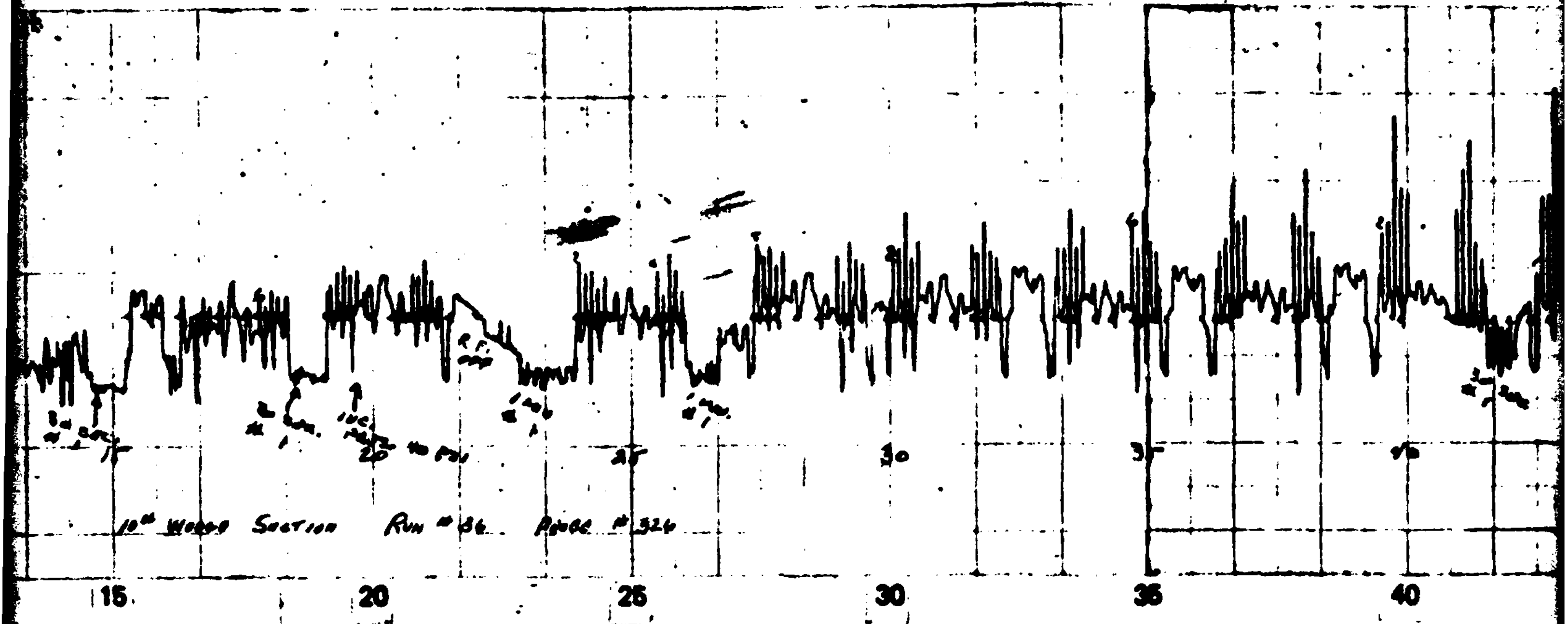
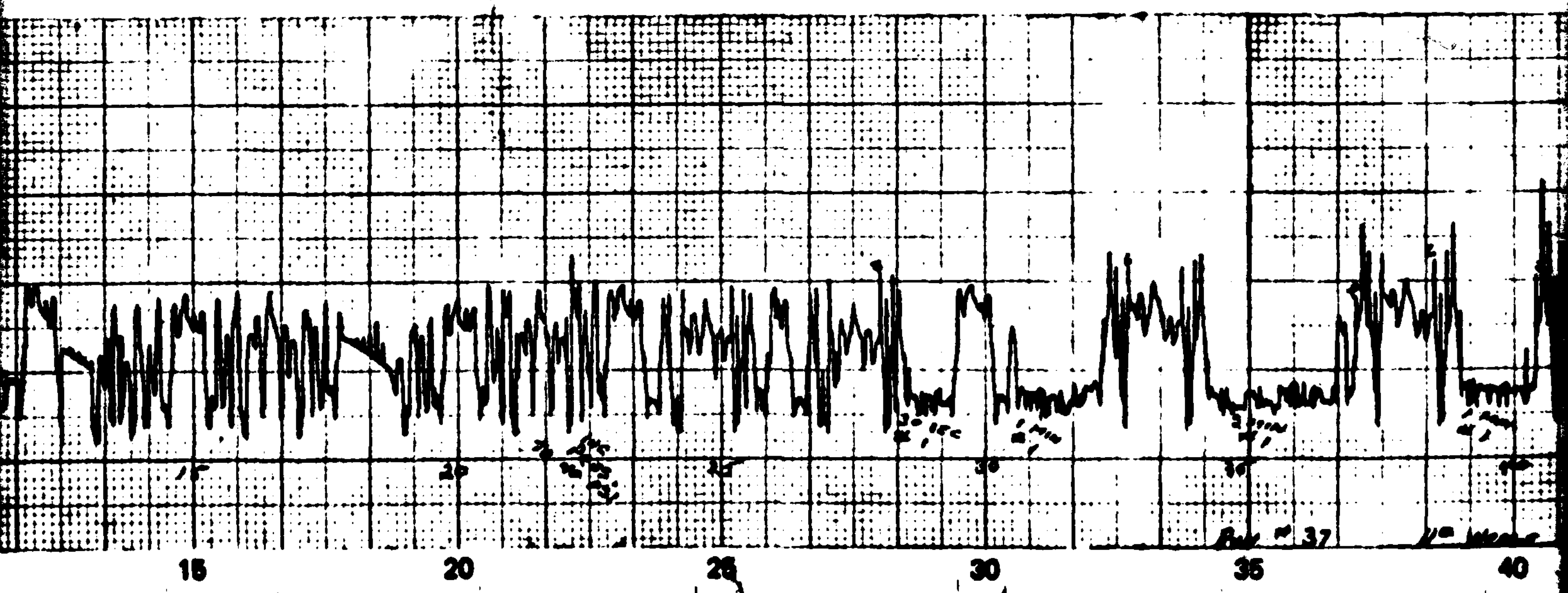


Figure E–24. Temperature Printout for 11th Wedge Section (Run 37)

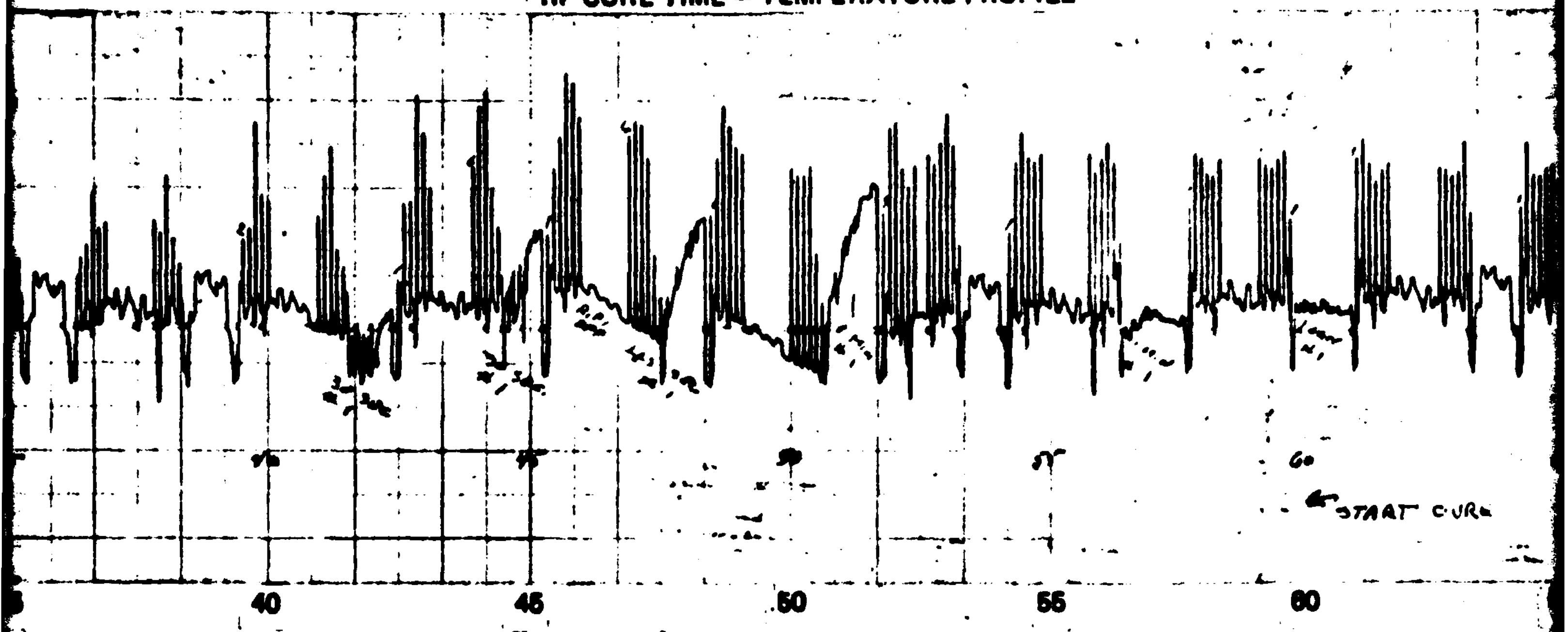


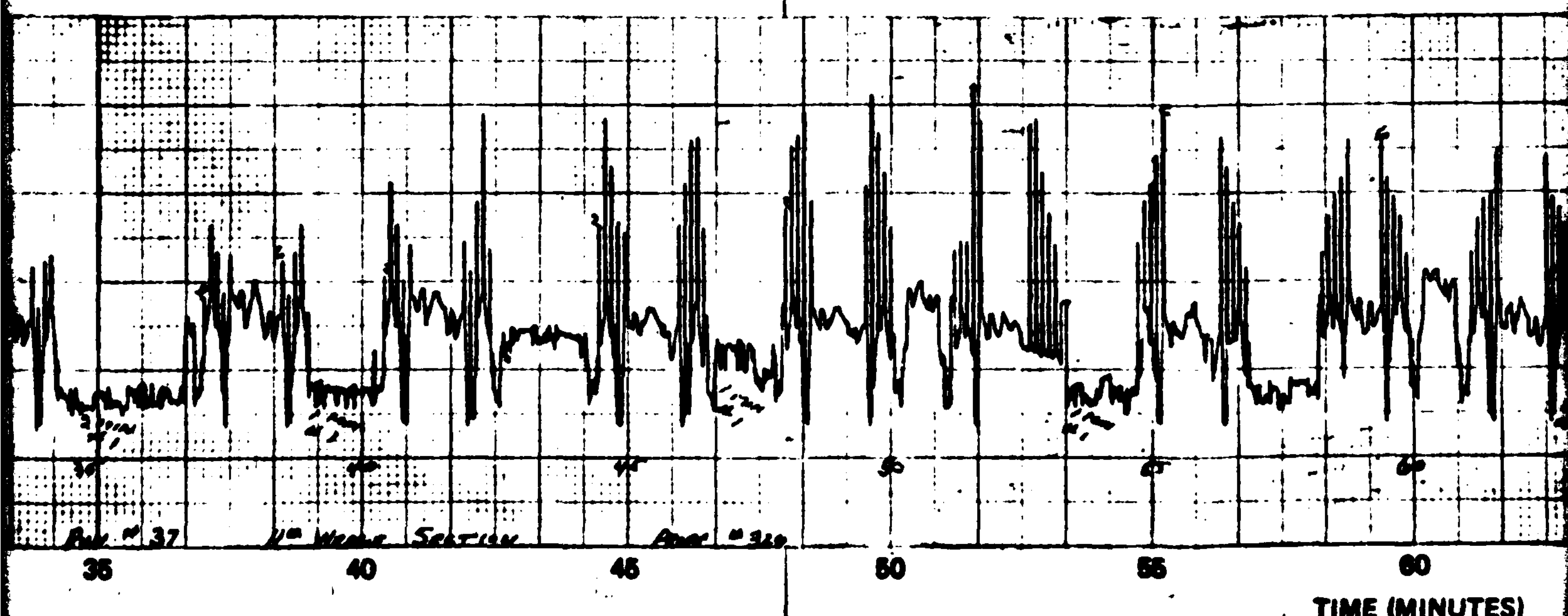
(Number 36)

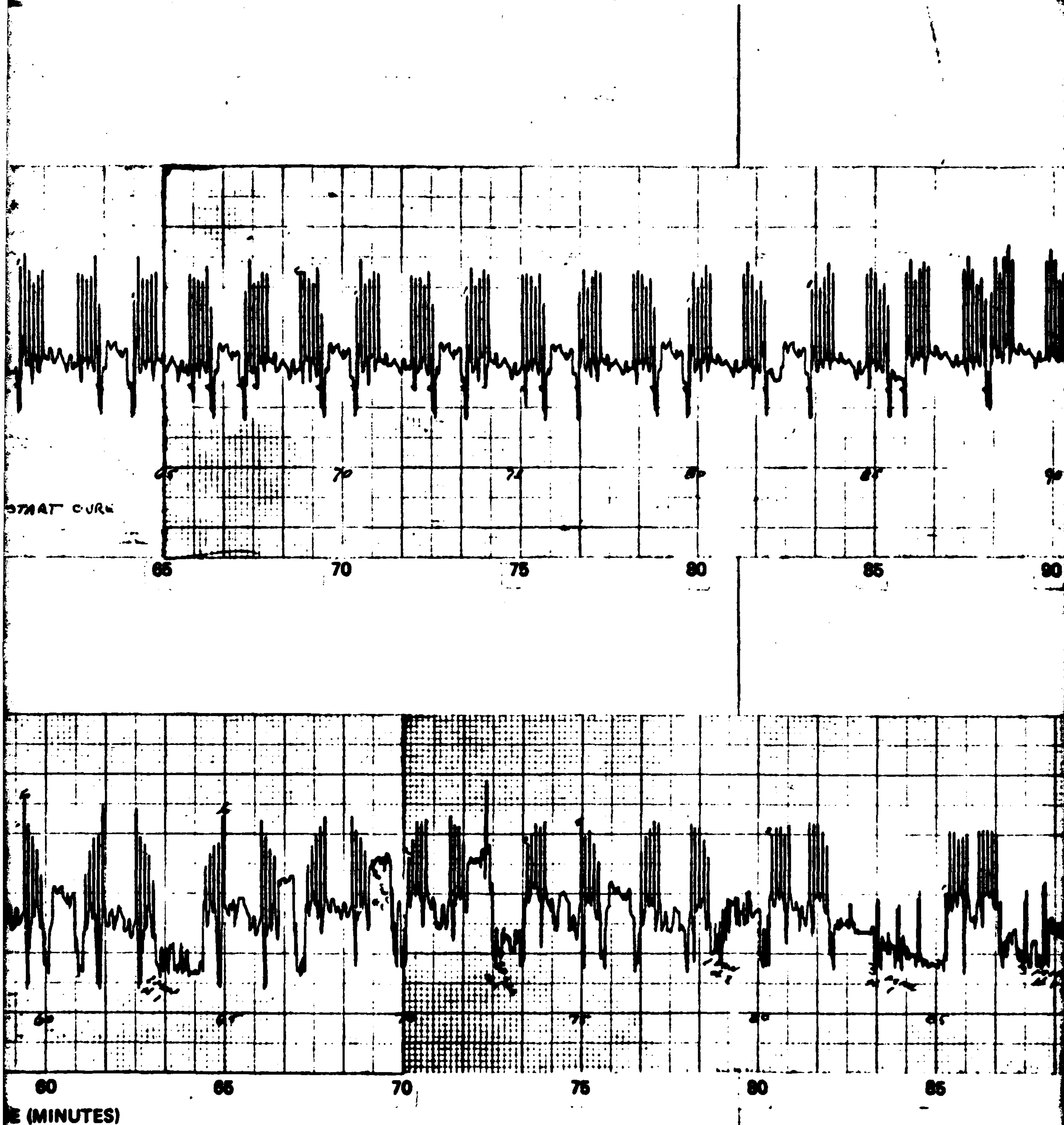


(Run 37)

RF CURE TIME – TEMPERATURE PROFILE

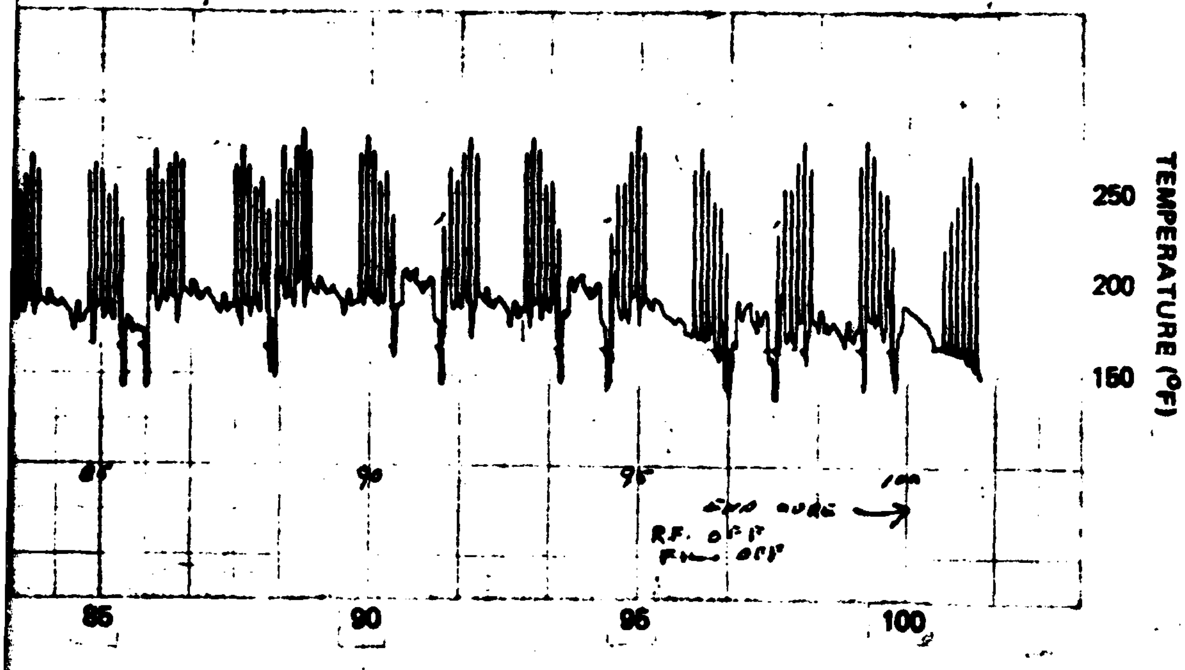


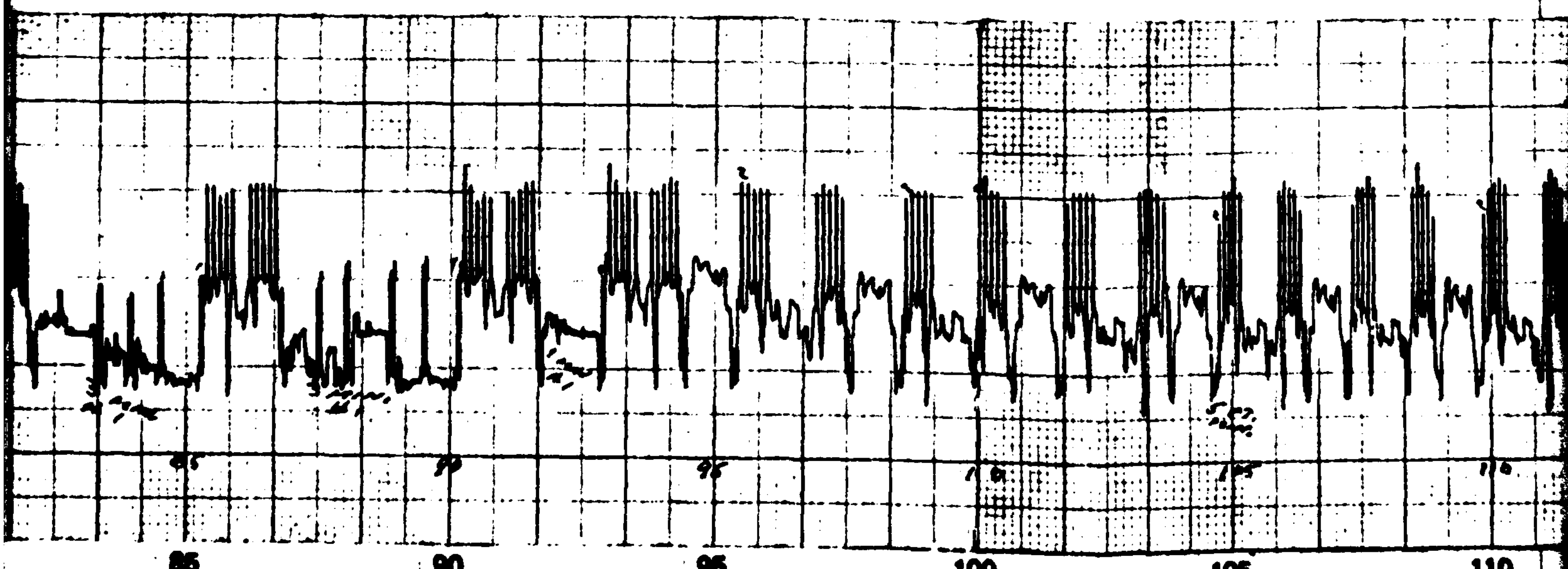




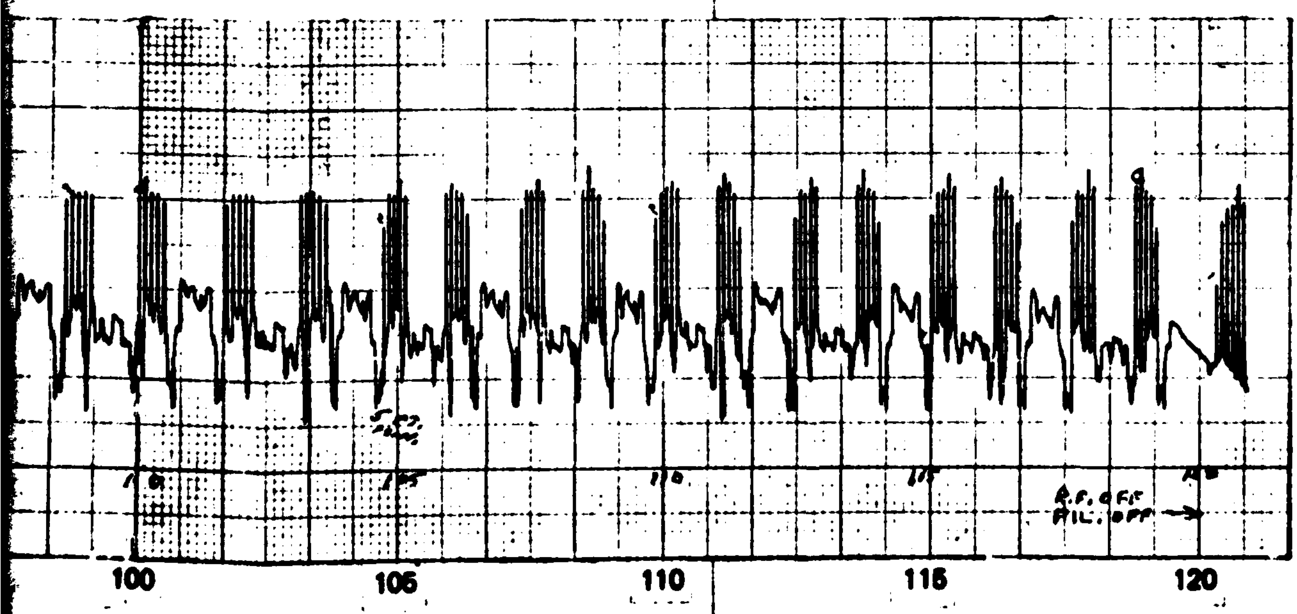
1 4

1


250
200
150
TEMPERATURE (°F)
85
90
95
100


85
90
95
100
105
110

TEMPERATURE (°F)
250
200
150
100



TEMPERATURE (°F)
250
200
150
R.F. OFF
FIL. OFF
100
106
110
116
120

APPENDIX F
PROCESSING PARAMETERS

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

Part Identification:
1st Govt Wedge SP250-E-33
Date:
5-22-79
Time Started:
1:22
Time Finished:
3:15pm
Type of Tooling:
Polypropylene Molds

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
RF Power Levels:																			
1. Line Voltage	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485
2. Filament Voltage	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
3. Grid Current	725 675	725 675	725 675	725 675	725 675	725 675	725 675	725 675	725 675	725 675	725 675	725 675	725 675	725 675	725 675	725 675	725 675	725 675	725 675
4. Plate Current	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1
Electrode Spacing (Dial Setting No.)	15	15	15	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Bag Pressure (PSIG)	10	10	20	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Temperature °F Pos. No. (R to L)																			
1	–	–	–	–	163	163	163	145	185	157	190	200	200	205	205	205	210	210	210
2	–	–	–	–	163	160	163	155	180	165	165	185	190	220	205	215	225	230	235
3	–	–	–	–	165	165	165	170	180	180	205	208	205	242	230	243	240	230	230
4	–	–	–	–	165	170	210	185	190	200	218	230	225	205	245	240	240	235	235
5	–	–	–	–	180	160	180	190	210	205	190	198	215	220	218	225	225	227	215
6	–	–	–	–	185	170	208	210	215	223	218	225	220	220	230	235	235	240	235
Belt Speed Ft/Min	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	2.5	2.5	2.5	4.5
Frequency: 89-93 MHZ																			

Part Identification:
SP 250 E-33 2nd Govt Wedge
Date:
5-29-79
Time Started:
9:00AM–1:20PM
Time Finished:
3:15PM
Type of Tooling:
Polypropylene Molds

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																																
1. Line Voltage	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485
2. Filament Voltage	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15
3. Grid Current	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700
4. Plate Current	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05	0.6 1.05
Electrode Spacing (Dial Setting No.)	13.9	13.9	13.9	13	13.9	13.9	13.9	13.9	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Bag Pressure (PSIG)	10	10	10	20	20	20	20	20	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Temperature °F Pos. No. (R to L)							*	**			‡						‡	‡			‡		‡		‡	‡				‡		
1	–	–	150	150	180	190	–	–	190	190	175	185	190	185	185	188	198	190	210	210	210	210	205	210	215	215	218	218	218	210	215	212
2	–	–	150	150	180	195	–	–	185	193	175	188	190	190	198	195	215	200	215	223	215	217	208	205	208	210	212	207	210	205	210	203
3	–	–	150	178	185	215	–	–	190	195	176	190	190	195	200	200	205	207	210	215	210	208	200	195	200	200	204	205	205	200	203	202
4	–	–	150	213	195	225	–	–	190	195	178	–	–	193	190	195	190	200	200	203	197	195	190	190	195	195	200	200	200	195	205	203
5	–	–	150	170	205	230	–	–	195	198	198	–	–	180	190	195	185	190	185	195	193	193	180	–	–	190	193	192	193	185	197	195
6	–	–	150	200	205	207	–	–	200	205	180	–	–	180	200	200	180	200	185	192	190	180	175	–	–	185	190	190	190	185	195	195
Belt Speed Ft/Min	4.5	4.5	4.5	4.5	4.5	4.5	Static		4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5														

*Static application of RF for 1 minute with probe on port No. 3
**Static application of RF for 1 minute with probe on port No. 2 – arcing of equipment.

‡ RF off for ports 4-5-6
‡ RF off for all ports

Frequency 90-93.5 MHZ

Part Identification: 3rd Govt Wedge SP250-33E
Date: 6-8-79
Time Started: 9:30AM
Time Finished: 11:15AM
Type of Tooling: Polypropylene Molds

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter
Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
RF Power Levels:																					
1. Line Voltage	475	475	475	475	475	475	475	475	475	475	475	475	475	475	475	475	475	475	475	475	475
2. Filament Voltage	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
3. Grid Current	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700
4. Plate Current	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0
Electrode Spacing (Dial Setting No.)	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Bag Pressure (PSIG)	10	10	10	10	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Temperature ^{0}F Pos. No. (R to L)																					
1	–	–	–	–	–	–	–	165	185	218	200	190	175	203	215	220	240	230	230	230	225
2	–	–	–	–	–	–	–	160	218	235	220	200	210	210	248	240	258	225	225	230	220
3	–	–	–	–	–	–	–	158	203	225	240	240	228	235	243	240	263	230	240	240	240
4	–	–	–	–	–	–	–	175	195	250	265	285	270	260	245	250	270	240	250	250	250
5	–	–	–	–	–	–	–	160	160	190	170	260	270	270	230	270	250	255	240	260	235
6	–	–	–	–	–	–	–	156	160	160	170	225	308	275	248	285	260	260	250	260	250
Belt Speed Ft/Min	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.6	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.6	4.5
Frequency 89.9-90 MHZ																					

Part Identification:
4th Wedge Section SP250-33E
Date: 6-21-74

Time Started: 8:00AM

Time Finished: 10:10AM

Type of Tooling:
Polypropylene Molds

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES

PROJECT NO.: 52283

ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60
RF Power Levels:												
1. Line Voltage	480	480	480	480	480	480	480	480	480	480	480	480
2. Filament Voltage	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
3. Grid Current	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700
4. Plate Current	0.6 0.9	0.6 0.9	0.6 0.9	0.6 0.9	0.6 0.9	0.6 0.9	0.6 0.9	0.6 0.9	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0
Electrode Spacing (Dial Setting No.)	14	14	14	14	14	14	14	14	14	14	14	14
Bag Pressure (PSIG)	5	5	5	5	5	5	20	20	35	35	35	35
Temperature ^{o}F Pos. No. (R to L)												
1	–	–	–	140	–	–	–	–	–	–	–	–
2	–	–	–	140	–	–	–	–	–	205	190	235
3	–	–	–	145	–	–	–	–	–	210	210	235
4	–	–	–	140	–	–	–	–	–	175	205	220
5	–	–	–	140	–	–	–	–	–	–	–	–
6	–	–	–	145	–	–	–	–	–	–	185	215
Belt Speed Ft/Min	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Frequency 90-95 MHZ Dwell 7 Sec	†	†		‡								

ACTIVITY	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:												
1. Line Voltage	480	480	480	480	480	480	480	480	480	480	480	480
2. Filament Voltage	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
3. Grid Current	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700	750 700
4. Plate Current	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 0.9	0.6 0.9	0.6 0.9	0.6 0.9
Electrode Spacing (Dial Setting No.)	14	14	14	14	14	14	14	14	14	14	14	14
Bag Pressure (PSIG)	35	35	35	35	35	35	35	35	35	35	35	35
Temperature ^{o}F Pos. No. (R to L)												
1	–	–		–	–	195	193	220	235	225	235	190
2	255	255	220	290	230	250	245	250	240	230	250	210
3	248	240	–	250	230	245	235	245	240	225	225	205
4	255	255	255	270	245	245	240	250	240	240	240	225
5	290	260	260	–	–	235	245	245	245	230	250	235
6	305	260	275	255	245	245	260	255	250	250	255	245
Belt Speed Ft/Min	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Frequency 90-95 MHZ Dwell 7 Sec											‡	‡

† RF off for ports 4-5-6
‡ RF off for all ports

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

Part Identification: 5th Wedge Section

Date: 7-19-79
Time Started: 9:40 AM
Time Finished: 11:40 AM
Type of Tooling: Polypropylene

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter
Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480
2. Filament Voltage	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
	650	850	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650
3. Grid Current	675	675	675	675	675	675	675	675	675	675	675	675	675	675	675	675	675	675	675	675	675	675	675	675
	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4. Plate Current	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Electrode Spacing (Dial Setting No.)	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	12.7	12.7	12.7	12.7	12.7	12.7
Bag Pressure (PSIG)	10	10	10	10	10	10	10	20	20	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Temperature ^{o}F Pos. No. (L to R)																								
1	–	–	–	–	–	–	–	–	–	175	175	175	–	–	145	–	200	190	225	220	210	205	205	205
2	–	–	–	–	–	–	–	–	–	225	175	175	205	–	155	–	195	215	205	205	205	200	195	205
3	–	–	–	–	–	–	–	–	195	250	210	255	230	225	170	–	205	226	220	220	220	220	220	228
4	–	–	–	–	–	–	–	–	285	220	240	250	240	230	185	–	220	240	230	230	233	235	235	240
5	–	–	–	–	–	–	–	–	280	185	220	220	–	265	265	–	235	230	250	245	240	245	230	235
6	–	–	–	–	–	–	–	–	220	155	165	165	175	275	265	–	205	230	240	245	245	250	250	255
Belt Speed Ft/Min	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5

Frequency 92-97 MHz

Part Identification: 6th
Wedge Section

Date: 8-16-79
Time Started: 8:40 AM
Time Finished: 10:40 AM
Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750
3. Grid Current	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4. Plate Current	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Electrode Spacing (Dial Setting No.)	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Bag Pressure (PSIG)	10	10	10	10	10	10	10	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Temperature °F Pos. No. (L to R)																								
1	–	–	–	–	–	–	153	155	–	160	165	165	168	170	–	–	–	170	160	–	200	200	–	175
2	–	–	–	–	–	–	170	170	–	180	180	180	185	165	165	170	–	175	190	–	210	240	200	205
3	–	–	–	–	–	–	175	175	190	185	190	190	203	200	185	215	215	230	225	225	220	235	205	203
4	–	–	–	–	–	–	170	170	190	180	195	195	238	245	220	225	215	220	215	215	215	235	215	207
5	–	–	–	–	–	–	160	160	–	170	190	190	250	230	170	–	150	175	200	200	–	190	–	185
6	–	–	–	–	–	–	160	160	–	165	175	175	170	190	175	215	250	245	230	225	225	240	215	210
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Frequency 90-93 MHz

Part Identification: 7th
Wedge Section
0° Fiber
Date: 8 29 79
Time Started: 8:50 AM
Time Finished: 10:50 AM
Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter
Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
HF Power Levels:																								
1. Line Voltage	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
	730	730	730	730	730	730	730	730	730	730	730	725	725	725	725	725	725	725	725	725	725	725	725	725
3. Grid Current	700	700	700	700	700	700	700	700	700	700	700	675	675	675	675	675	675	675	675	675	675	675	675	675
	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4. Plate Current	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.0	1.0	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Electrode Spacing (Dial Setting No.)	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	12.4	12.4	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Bag Pressure (PSIG)	10	10	10	10	10	40																		
Temperature °F Pos. No. (L to R)																								
1	–		–	150	–	160	–	–	170	180	185	185	190	200	–	205	195	190	195	190	205	195	190	–
2	–	–	–	155	–	170	–	160	185	200	210	210	215	225	–	250	260	245	250	235	245	230	230	230
3	–	–	–	160	–	180	–	170	180	200	205	210	225	255	–	290	275	255	250	240	240	240	235	240
4	–	–	–	160	–	185	–	180	193	210	210	220	250	255	–	270	255	260	250	246	245	245	250	255
5	–	–		160	–	185	–	175	185	200	205	215	230	262	–	230	215	210	210	205	210	–	200	185
6	–	–	–	160	–	180	–	170	185	200	205	215	225	240	–	285	260	265	255	250	245	250	250	255
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Frequency 90-93 MHz																								

Part Identification: 8th
Wedge Section
0° Fiber
Date: 9 5 79
Time Started: 8:25 AM
Time Finished: 10:25 AM
Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter
Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	
RF Power Levels:																									
1. Line Voltage	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	
3. Grid Current	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	
	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	
4. Plate Current	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Electrode Spacing (Dial Setting No.)	11.5	11.5	11.5	11.5	11.5	11.5	11.5		12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	
Bag Pressure (PSIG)	10	10	10	10	10	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	
Temperature °F Pos. No. (L to R)																									
1	–	–	–	–	165	–	175	180	–	–	200	–	200	210	235	225	220	220	215	210	215	215	210	205	
2	–	–	–	–	175	190	195	200	210	210	215	–	215	235	280	270	250	240	235	230	230	230	230	225	
3	–	–	–	–	165	185	195	210	220	225	230	220	235	250	265	250	245	240	235	240	235	235	235	235	
4	–	–	–	–	160	185	200	210	220	225	245	260	250	260	240	240	240	245	245	245	245	250	250	250	
5	–	–	–	–	155	180	195	200	210	210	230	285	255	235	235	235	230	235	235	235	235	235	245	260	
6	–	–	–	–	150	180	195	200	220	225	235	235	250	255	245	260	245	245	240	240	240	240	240	240	
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Frequency 90-92 MHz																									

Part Identification: 9th
Wedge Section
0° Fiber

Date: 11-15-79

Time Started: 9:20 AM PM

Time Finished: 11:20 AM PM

Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES

PROJECT NO.: 52283

ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	740	750	750	750	750
3. Grid Current	725	725	725	725	725	725	725	725	725	725	725	725	725	725	725	725	725	725	725	725	725	725	725	725
	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
4. Plate Current	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Electrode Spacing (Dial Setting No.)	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Bag Pressure (PSIG)	10	10	10	10	10	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Temperature $^{\circ}F$ Pos. No. (L to R)																								
1	–	–	175	180	150	205	190	190	–	–	–	–	205	–	–	–	–	–	–					
2	–	–	175	185	160	190	180	185	–	–	–	200	210	200	200	205	–	200	–	200	200	200	205	215
3	–	–	175	200	165	200	185	205	215	220	235	235	225	225	220	220	220	220	220	225	225	225	230	245
4	–	–	175	180	175	205	180	210	220	230	260	260	240	235	230	230	235	235	235	245	245	245	265	275
5	–	–	175	170	180	195	180	205	210	240	275	275	245	235	230	235	240	245	240	255	255	250	265	280
6	–	–	175	195	190	200	–	205	225	225	230	285	250	240	235	235	235	240	235	235	235	240	245	255
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Frequency 90-92 MHz

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

Part Identification: 10th Wedge Section

Date: 11-27-79
Time Started: 12:30 PM
Time Finished: 2:10 PM
Type of Tooling: Polypropylene

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter
Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480				
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2				
	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735				
3. Grid Current	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700				
	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
4. Plate Current	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0				
Electrode Spacing (Dial Setting No.)	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12				
Bag Pressure (PSIG)	10	10	10	10	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40				
Temperature °F Pos. No. (L to R)																								
1	–	–	–	–	–	–	–	–	225	185	225	265	240	240	245	235	235	240	230	230				
2	–	–	–	185	190	215	210	220	260	240	265	275	275	275	265	260	265	260	255	255				
3	–	–	160	185	200	205	215	225	280	260	280	265	255	250	250	250	250	255	255	255				
4	–	–	170	190	210	230	230	310	315	255	265	265	255	255	260	260	260	275	275	265				
5	–	–	165	180	185	210	210	245	310	255	265	260	260	260	265	270	265	280	285	280				
6	–	–	160	185	200	205	225	245	290	260	270	265	260	260	260	260	260	270	275	265				
Belt Speed Ft/Min	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4				
Frequency 90-92 MHz																								

Part Identification: 11th
Wedge Section

Date: 11-29-79
Time Started: 12:45 PM
Time Finished: 2:45 PM
Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735
3. Grid Current	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4. Plate Current	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Electrode Spacing (Dial Setting No.)	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Bag Pressure (PSIG)	10	10	10	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Temperature °F Pos. No. (L to R)																								
1	–	–	–	–	–	–	–	160	–	–	–	–	–	–	–	185	200	206	160	–	–	–	170	–
2	–	–	–	170	–	150	190	205	230	240	225	215	225	230	225	260	266	265	255	250	235	240	240	235
3	–	–	–	170	–	185	230	235	280	275	245	235	236	245	240	255	255	255	256	255	256	255	255	255
4	–	–	–	170	–	205	215	235	265	280	255	250	240	260	255	256	245	245	250	256	255	266	255	265
5	–	–	–	180	–	180	195	200	235	295	270	260	245	260	250	250	250	250	250	260	260	280	266	265
6	–	–	–	165	–	205	215	220	230	245	295	280	265	266	255	260	250	245	250	250	255	255	255	260
Belt Speed Ft/Min	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Frequency 90-92 MHz

Part Identification: 1st Constant Section Laminate SP250-33E

Date: 6-14-79

Time Started: 9:25AM

Time Finished: 10:55AM

Type of Tooling: Polypropylene Molds

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES

PROJECT NO.: 52283

ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
RF Power Levels:																			
1. Line Voltage	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485
2. Filament Voltage	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
3. Grid Current	750 675	750 675	750 675	750 675	750 675	750 675	750 675	750 675	750 675	750 675	750 675	750 675	750 675	750 675	750 675	750 675	750 675	750 675	750 675
4. Plate Current	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1
Electrode Spacing (Dial Setting No.)	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Bag Pressure (PSIG)	5	5	15	15	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Temperature °F																			
Pos. No. (R to L)																			
1	–	–	170	190	184	202	210	205	210	235	270	262	250	255	238	243	245	240	218
2	–	–	175	195	192	205	220	236	255	263	245	220	235	235	233	237	237	237	220
3	–	–	175	195	198	207	225	295	245	251	245	240	245	250	244	245	248	248	220
4	–	–	175	190	198	206	225	273	240	253	235	228	235	238	235	237	237	240	225
5	–	–	170	188	198	200	215	236	245	248	243	210	235	223	236	236	220	237	220
6	–	–	164	173	193	190	205	210	195	270	263	240	240	238	238	235	235	235	220
Belt Speed Ft/Min	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Frequency 89-93 MHZ			‡	‡	‡	‡	‡		△			☆	‡		‡	‡		‡	‡

‡ RF off for all ports
△ RF off for 2-3-4-5
☆ RF off for 6 & 1

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

Part Identification: 2nd Constant Thickness Section SP250-456E
Date: 6-27-79
Time Started: 8:10AM
Time Finished: 10:10AM
Type of Tooling: Polypropylene Molds

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter
Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
RF Power Levels:																			
1. Line Voltage	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480
2. Filament Voltage	7.3	7.3	7.3	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.9	6.9	6.9	6.9	6.9	6.9	6.9
3. Grid Current	750 695	750 695	750 695	750 695	750 695	750 695	750 695	750 695	750 695	750 695	750 695	750 695	750 695	750 695	750 695	750 695	750 695	750 695	750 695
4. Plate Current	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.1	0.6 1.0	0.6 1.0	0.6 1.0	0.6 1.0	0.6 0.9	0.6 0.9	0.6 0.9	0.6 0.9	0.6 0.9	0.6 0.9	0.6 0.9
Electrode Spacing (Dial Setting No.)	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Bag Pressure (PSIG)	10	10	20	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Temperature ^{0}F Pos. No. (R to L)																			
1	–	175	172	205	205	214	250	255	250	245	225	240	–	240	240	250	240	240	–
2	–	183	183	200	210	220	300	280	260	265	230	240	–	247	257	260	240	260	–
3	–	190	193	200	220	222	310	260	248	240	230	230	–	147	253	260	250	245	–
4	–	190	193	198	215	223	288	260	260	263	235	235	–	236	245	255	245	245	–
5	–	185	188	185	210	210	215	225	248	–	250	230	–	–	237	243	245	245	–
6	–	180	175	184	205	205	190	190	203	250	285	260	–	254	260	264	240	245	–
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Frequency 90-95 MHZ ‡ RF off for all ports					‡	‡			‡			‡			‡				‡

Part Identification: 3rd Constant Thickness Section SP250-33E
Date: 7-23-79
Time Started: 8:15AM
Time Finished: 9:50AM
Type of Tooling: Polyproplyene Molds

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter
Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
RF Power Levels:																			
1. Line Voltage	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480
2. Filament Voltage	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
3. Grid Current	670	670	670	670	670	670	670	670	670	670	670	670	670	670	670	670	670	670	670
4. Plate Current	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Electrode Spacing (Dial Setting No.)	13.5	–	–	–	–	–	–	–	–	–	–	–	–	–	12.8	–	–	–	–
Bag Pressure (PSIG)	10	10	10	10	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Temperature ^{o}F Pos. No. (R to L)																			
1	–	–	200	–	205	190	165	–	180	190	325	300	275	275	270	275	250	265	255
2	–	–	215	–	185	260	240	–	220	200	245	230	240	240	245	285	255	255	260
3	–	–	225	–	250	270	275	–	220	285	240	240	255	260	270	295	365	280	275
4	–	–	240	–	285	260	235	–	225	240	240	245	265	275	280	285	275	280	285
5	–	–	220	–	175	275	275	–	230	215	185	175	200	190	210	260	255	245	250
6	–	–	200	–	200	180	180	–	230	205	275	200	250	250	250	260	235	245	260
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Frequency 92-98 MHZ						‡	‡	‡											

‡ RF off for all ports

Part Identification: 4th
Constant Thickness Section
0^0 Fiber

Date: 8-22-79

Time Started: 8:15 AM

Time Finished: 9:45 AM

Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES

PROJECT NO.: 52283

ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480						
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2						
	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750						
3. Grid Current	715	715	715	715	715	715	715	715	715	715	715	715	715	715	715	715	715	715						
	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
4. Plate Current	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0						
Electrode Spacing (Dial Setting No.)	12	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11						
Bag Pressure (PSIG)	10	10	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40						
Temperature °F Pos. No. (L to R)																								
1	-	155	180	195	205	200	220	245	190	220	225	210	205	190	185	-	200	150						
2	-	175	200	210	225	225	245	245	265	260	245	220	235	230	230	230	200	225						
3	-	165	190	205	220	230	245	250	210	210	210	215	210	220	225	225	240	225						
4	-	175	190	205	210	220	250	265	225	230	230	230	235	236	240	240	230	235						
5	-	155	180	190	200	195	225	250	240	245	235	225	225	210	205	230	225	210						
6		145	170	185	195	190	200	-	-	220	235	210	215	210	205	230	-	185						
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5						
Frequency 89.93 MHz																								

Part Identification: 5th
Constant Thickness Section
8° Fiber

Date: 8 31 79

Time Standard: 8:00 AM

Time Finished: 9:30 AM

Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES

PROJECT NO.: 52283

ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480						
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2						
	750	750	750	760	750	760	760	760	750	750	750	760	750	750	760	750	750	760						
3. Grid Current	725	725	725	725	725	726	726	725	725	725	725	726	725	726	726	726	725	725						
	0.5	0.6	0.6	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.5	0.6	0.6	0.5	0.6	0.5	0.5						
4. Plate Current	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0						
Electrode Spacing (Dial Setting No.)	11.5	11.5	11.5	11.5	11.0	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3						
Bag Pressure (PSIG)	10	10	10	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40						
Temperature °F Pos. No. (L to R)																								
1	--	-	170	180	195	210	190	210	225	240	235	230	220	220	220	215	215	215						
2	-	-	175	210	215	225	230	260	265	250	260	250	245	245	245	250	250	250						
3	-	-	180	210	210	220	225	275	265	260	255	260	250	255	255	265	255	260						
4	-	-	170	205	215	225	230	270	250	245	260	260	250	255	255	260	260	265						
5	-	-	160	180	205	225	240	245	205	215	225	210	200	200	205	200	200	--						
6	-	-	160	195	210	200	205	215	205	215	260	275	265	260	255	255	255	255						
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5						
Frequency 98.93 MHz																								

Part Identification: 6th
Constant Thickness Section
0° Fiber

Date: 9-10-79

Time Started: 8:30 AM

Time Finished: 9:40 AM

Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES

PROJECT NO.: 52283

ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485									
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2									
	760	760	760	760	760	760	760	760	760	760	760	760	760	760	760									
3. Grid Current	725	725	725	725	725	725	725	725	725	725	725	725	725	725	725									
	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5									
4. Plate Current	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0									
Electrode Spacing (Dial Setting No.)	12	12	12	12	12	10	10	11	11	11	11	11	11	11	11									
Bag Pressure (PSIG)	10	–	40	40	40	40	40	40	40	40	40	40	40	40	40									
Temperature °F Pos No. (L to R)																								
1	–	–	170	206	205	215	250	260	270	265	260	255	255	255	255									
2	–	–	185	225	225	270	290	260	245	245	246	240	235	236	236									
3	–	–	180	210	210	250	265	275	275	270	270	270	270	275	275									
4	–	–	200	210	210	260	260	275	275	270	265	265	265	265	265									
5	–	–	190	195	195	230	240	260	260	250	250	250	246	250	250									
6	–	–	190	205	205	215	235	270	280	270	265	260	255	250	250									
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5									
Frequency 90–92 MHz																								

Part Identification: 7th
Constant Thickness Section
0° Fiber
Date: 10-23-79
Time Started: 9:22 AM
Time Finished: 10:36 AM
Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter
Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485									
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2									
	760	760	760	760	760	760	760	760	760	760	760	760	760	760	760									
3. Grid Current	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735									
	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6									
4. Plate Current	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0									
Electrode Spacing (Dial Setting No.)	12	12	12	12	12	10	10	10	10	11	11	11	11	11	11									
Bag Pressure (PSIG)	10	–	40	40	40	40	40	40	40	40	40	40	40	40	40									
Temperature °F Pos. No. (L to R)																								
1	–	–	–	170	190	200	225	250	280	275	265	260	255	250	260									
2	–	–	–	200	215	250	285	295	265	260	255	255	260	265	270									
3	–	–	–	210	230	275	270	250	230	225	220	225	230	230	235									
4	–	–	–	205	235	295	290	275	255	250	250	250	255	265	270									
5	–	–	–	200	220	255	250	260	235	230	230	230	230	235	235									
6	–	–	–	205	200	215	230	260	260	255	260	245	245	245	245									
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5									
Frequency 91.92 MHz																								

Part Identification: 8th
Constant Thickness Section
0/90° Fiber

Date: 10-30-79
Time Started: 1:57 PM
Time Finished: 3:12 PM
Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES

PROJECT NO.: 52283

ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485									
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2									
3. Grid Current	735	735	735	735	735	735	735	735	735	735	735	735	735	735	735									
	705	705	705	705	705	705	705	705	705	705	705	705	705	705	705									
4. Plate Current	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5									
	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0									
Electrode Spacing (Dial Setting No.)	11	11	11	11	11.5	11.5	11	11	10	10	10	10	10	10	10									
Bag Pressure (PSIG)	10	10	40	40	40	40	40	40	40	40	40	40	40	40	40									
Temperature °F Pos No (L to R)																								
1	–	–	165	180	185	185	235	320	285	245	235	230	220	205	210									
2	–	–	170	215	205	230	265	365	310	280	275	275	265	265	265									
3		-	170	220	180	230	275	315	310	280	275	275	260	250	250									
4			165	225	225	225	275	315	305	275	275	275	265	265	260									
5			160	200	220	225	260	235	200	225	180	180	180	180	180									
6			155	190	225	210	225	–	200	275	275	275	260	250	250									
Belt Speed Ft Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5									
Frequency 50.91 MHz																								

Part Identification: 9th
Constant Thickness Section
145° Fiber
Date: 10-31-79
Time Started: 8:00 AM
Time Finished: 9:10 AM
Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter
Technician: W. Lashne

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	485	485	485	485	485	485	485	485	485	485	485	485	485	485										
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2										
	750	750	750	750	750	750	750	750	750	750	750	750	750	750										
3. Grid Current	700	700	700	700	700	700	700	700	700	700	700	700	700	700										
	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6										
4. Plate Current	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0										
Electrode Spacing (Dial Setting No.)	11.5	11.5	11.5	11.5	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0										
Bag Pressure (PSIG)	10	10	40	40	40	40	40	40	40	40	40	40	40	40										
Temperature °F Pos. No. (L to R)																								
1	–	–	170	195	210	235	275	285	280	265	260	265	265	265										
2	–	–	215	210	240	295	275	265	265	250	260	265	265	260										
3	–	–	220	215	265	295	265	260	265	255	260	260	260	265										
4	–	–	220	230	260	285	270	270	250	250	250	255	265	255										
5	–	–	210	230	230	235	270	305	270	260	260	265	260	265										
6	–	–	195	225	220	215	215	270	280	270	270	265	260	260										
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5										
Frequency 90.91 MHz																								

Part Identification: 10th
Constant Thickness Section
$\pm 45^{\circ}$ Fiber

Date: 11-7-79

Time Started: 12:20 PM

Time Finished: 1:30 PM

Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES

PROJECT NO.: 52283

ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	485	485	485	485	485	485	485	485	485	485	485	485	485	485										
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2										
	750	750	750	750	750	750	750	750	750	750	750	750	750	750										
3. Grid Current	710	710	710	710	710	710	710	710	710	710	710	710	710	710										
	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5										
4. Plate Current	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0										
Electrode Spacing (Dial Setting No.)	12	12	12	11	11	11	10	10	11	11	11	11	11	11										
Bag Pressure (PSIG)	10	10	40	40	40	40	40	40	40	40	40	40	40	40										
Temperature $^{\circ}F$ Pos. No. (L to R)																								
1	–	170	–	–	–	215	275	265	255	245	245	245	245	245										
2	–	175	195	250	250	275	290	270	260	255	255	250	250	255										
3	–	180	210	220	220	275	280	255	255	255	260	260	265	265										
4	–	180	205	230	230	260	280	265	255	250	250	245	250	245										
5	–	170	190	205	205	270	285	270	265	260	260	260	265	265										
6	–	165	185	205	205	220	240	265	260	260	255	250	250	250										
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	6										

Frequency 90-91 MHz

Part Identification: 11th Constant Thickness Section 0/90° Fiber

Date: 11-9-79

Time Started: 9:00 AM

Time Finished: 10:20 AM

Type of Tooling: Polypropylene

BOEING VERTOL COMPANY

A DIVISION OF THE BOEING COMPANY

PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES

PROJECT NO.: 52283

ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter

Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	485	485	485	485	485	485	485	485	485	485	485	485	485	485										
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	72.	7.2										
	760	760	760	760	760	760	760	760	760	760	760	760	760	760										
3. Grid Current	710	710	710	710	710	710	710	710	710	710	710	710	710	710										
	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5										
4. Plate Current	1.0	1.0	1.0	0.9	0.9	0.9	0.85	0.85	0.85	0.85	0.85	0.9	0.9	0.9										
Electrode Spacing (Dial Setting No.)	12	12	12	11	11	11	10.5	10.5	10.5	10.5	10.5	.11	11	11										
Bag Pressure (PSIG)	10	30	40	40	40	40	40	40	40	40	40	40	40	40										
Temperature °F Pos. No. (L to R)																								
1	–	175	–	170	210	240	270	260	280	260	265	265	265	260										
2	–	175	210	215	245	300	290	260	265	260	265	265	265	265										
3	–	180	220	220	255	315	290	260	265	265	270	275	270	270										
4	–	185	210	215	240	300	295	260	280	260	270	270	270	270										
5	–	175	210	215	235	265	280	280	270	265	270	275	270	270										
6	–	170	195	205	220	230	255	275	270	265	265	260	260	255										
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5										

Frequency 90-91 MHz

Part Identification: 12th
Constant Thickness Section

Date: 11-13-79
Time Started: 9:15 AM
Time Finished: 10:25 AM
Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter
Technician: W. Lashno

Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	56	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	485	485	485	485	485	485	485	486	485	485	485	486	486	486										
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2										
	750	750	750	750	750	750	750	750	750	750	750	750	750	750										
3. Grid Current	700	700	700	700	700	700	700	700	700	700	700	700	750	700										
	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5										
4. Plate Current	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0										
Electrode Spacing (Dial Setting No.)	12	12	12	12	12	12	11	11	11	11.5	11.5	11.5	11.5	11.5										
Bag Pressure (PSIG)	10	40	40	40	40	40	40	40	40	40	40	40	40	40										
Temperature °F Pos. No. (L to R)																								
1	–	170	–	–	195	230	275	255	280	270	265	260	255	250										
2	–	170	–	245	315	315	310	265	265	260	265	265	265	270										
3	–	170	–	230	240	295	275	265	260	260	265	270	270	280										
4	–	170	–	200	235	265	310	280	265	260	265	270	270	280										
5	–	165	–	180	205	225	285	300	280	270	265	270	270	270										
6	–	165	–	215	225	230	245	280	285	275	270	270	270	265										
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	6	5	5	5	5	5										

Frequency 90-91 MHz

Part Identification: 13th
Constant Thickness Section

Date: 11-21-79
Time Started: 12:35 AM
Time Finished: 1:15 AM
Type of Tooling: Polypropylene

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

PROJECT TITLE: RADIO FREQUENCY CURE OF EPOXY/GLASS COMPOSITES
PROJECT NO.: 52283
ELECTRODE SIZE 23-3/4 IN. X 17 IN.

Project Engineer: L. C. Ritter
Technician: W. Lashno

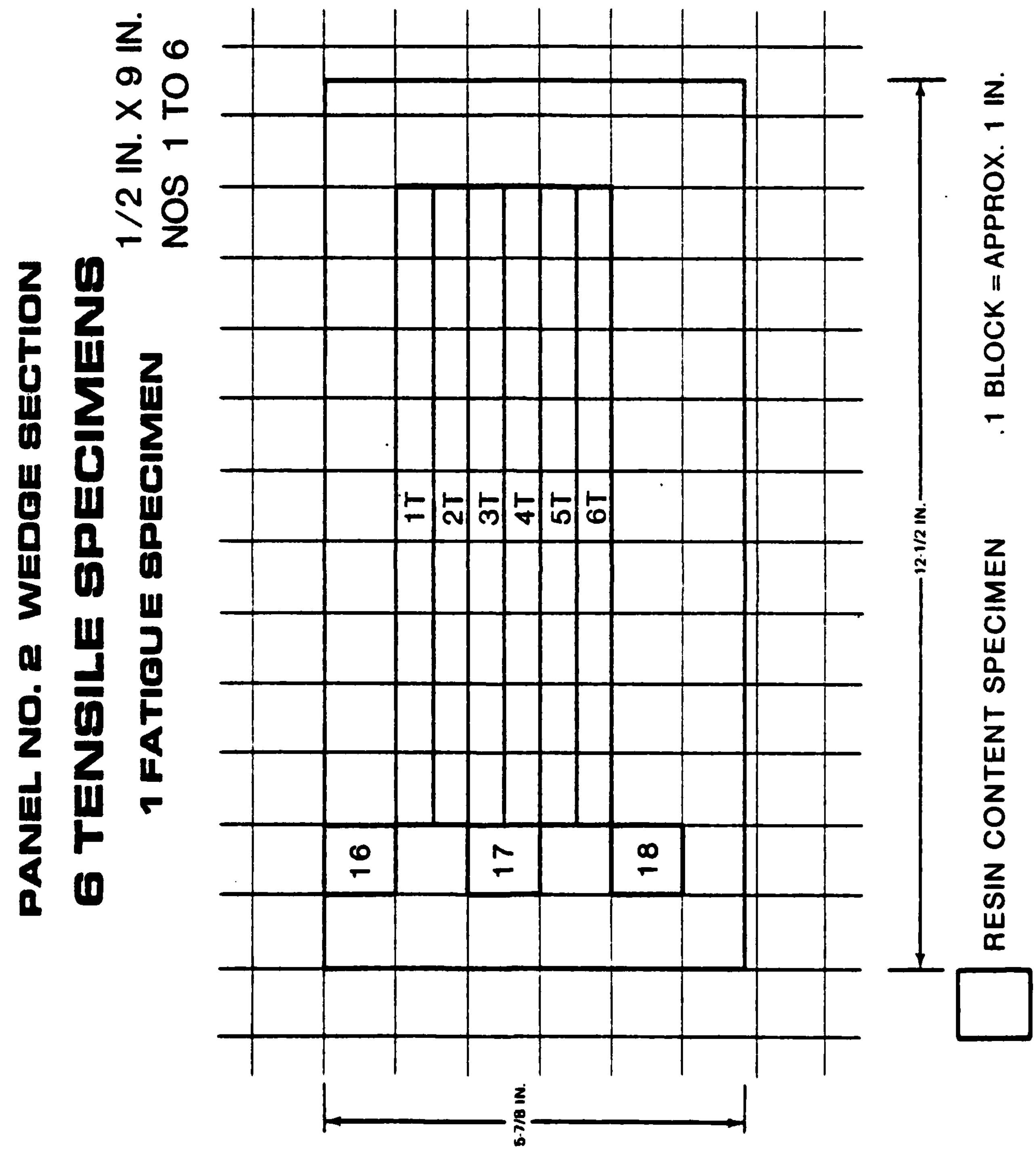
Time (Minutes) Accumulated

ACTIVITY	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
RF Power Levels:																								
1. Line Voltage	485	485	485	485	485	485	485	485	485	485	485	485	485	485										
2. Filament Voltage	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2										
	750	750	750	750	750	750	750	750	750	750	750	750	750	750										
3. Grid Current	720	720	720	720	720	720	720	720	720	720	720	720	720	720										
	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55										
4. Plate Current	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95										
Electrode Spacing (Dial Setting No.)	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11	11	11	11	11	11										
Bag Pressure (PSIG)	10	10	40	40	40	40	40	40	40	40	40	40	40	40										
Temperature °F Pos. No. (L to R)																								
1	–	160	–	–	170	195	205	275	275	275	265	255	260	255										
2	–	165	–	185	215	245	285	280	270	265	255	250	260	260										
3	–	175	–	200	225	265	280	260	265	265	265	265	275	280										
4	–	170	–	185	215	260	280	250	255	255	260	250	255	280										
5	–	160	–	175	200	220	265	265	275	275	265	260	260	265										
6	–	155	–	180	210	235	215	230	265	300	275	260	255	255										
Belt Speed Ft/Min	5	5	5	5	5	5	5	5	5	5	5	5	5	5										

Frequency 90-93 MHz

APPENDIX G

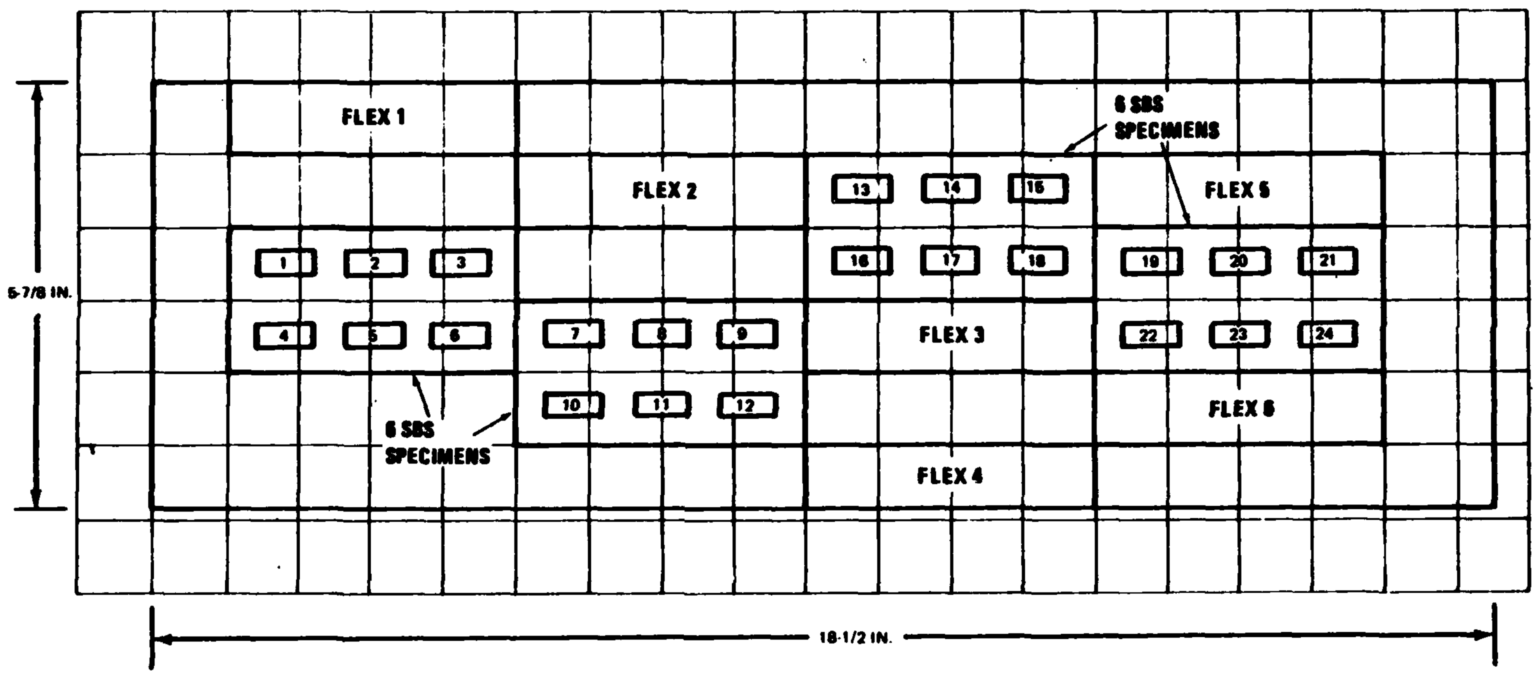
PANEL IDENTIFICATION AND TEST SPECIMEN LOCATION



PANEL NO. 3 WEDGE SECTION

6 FLEXURE SPECIMENS

1 IN. X 4 IN.
NOS 1 TO 6



24 SHORT BEAM SHEAR (SBS) SPECIMENS
0.25 IN. X 9t
NOS. 1 TO 24
t - THICKNESS

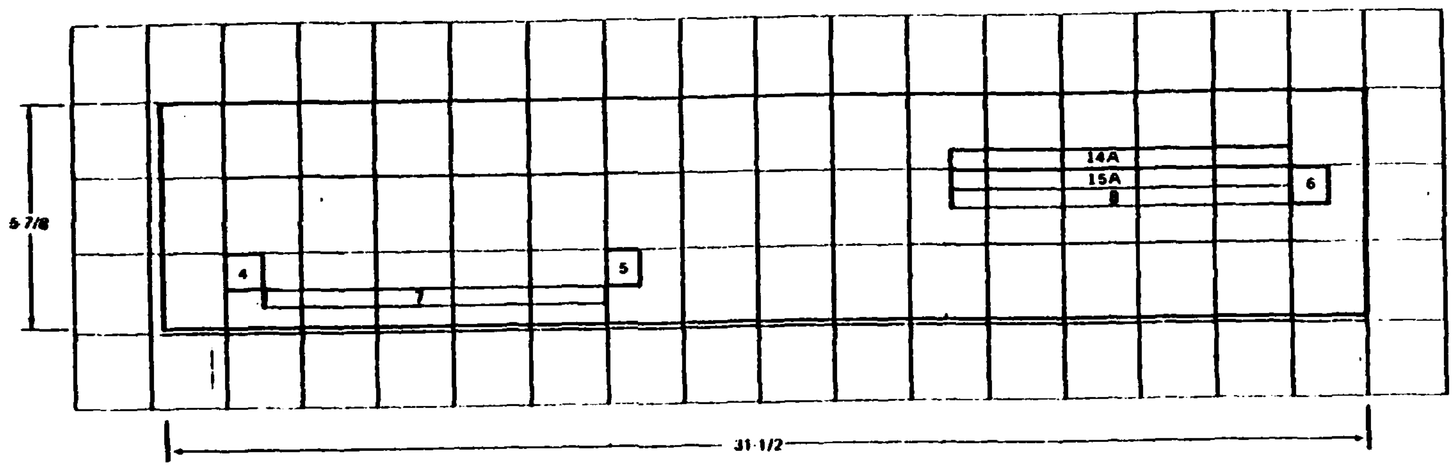
1 BLOCK = APPROX 1 IN.

PANEL NO. 4 WEDGE SECTION

2 TENSILE SPECIMENS

2 FATIGUE SPECIMENS

1/2 IN. X 9 IN.
NOS 7 AND 8



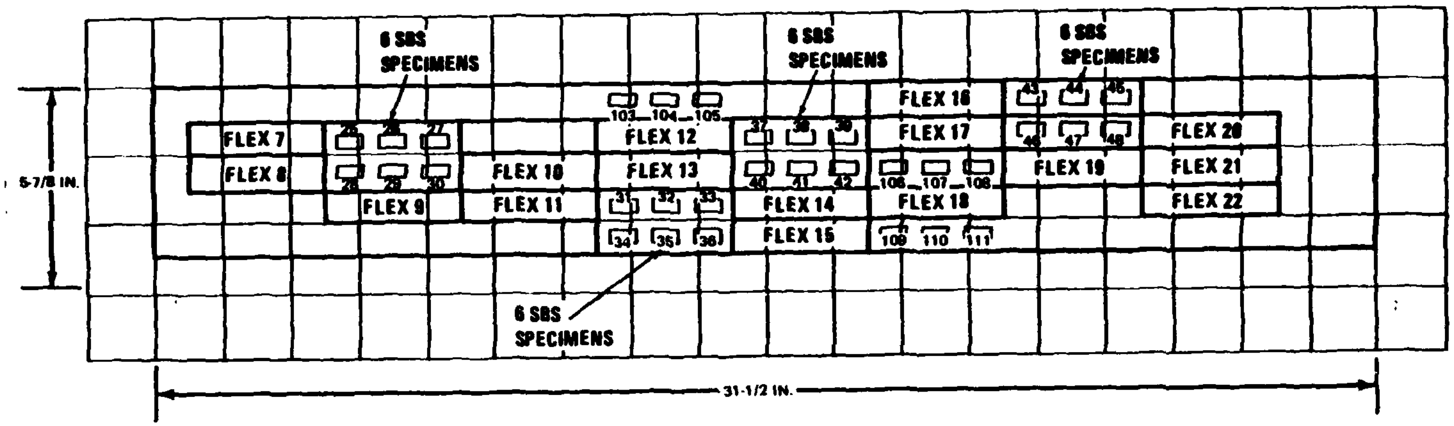
1 BLOCK = APPROX 2 IN.

☐ – RESIN CONTENT SPECIMENS

14A, 15A – RETEST SPECIMENS

PANEL NO. 5 WEDGE SECTION
16 FLEXURE SPECIMENS

1 IN. X 4 IN.
NOS 7 TO 22



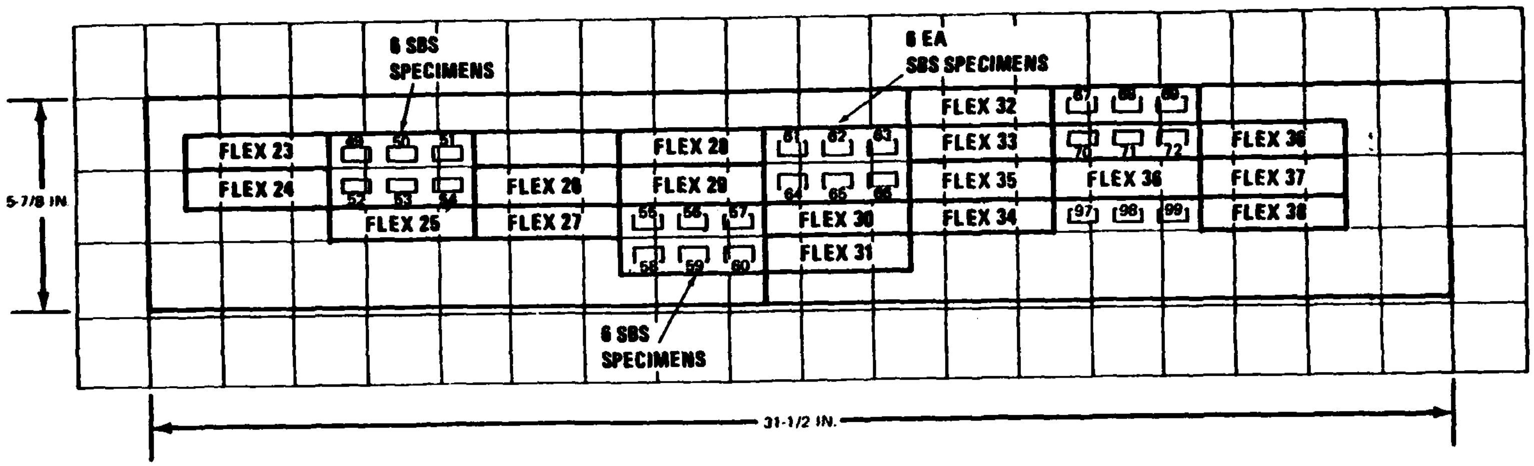
24 a z 24 *SHORT BEAM SHEAR SPECIMENS*
0.25 IN. X 9 t
NOS 25 TO 48
t — THICKNESS
103 THROUGH 111 — SBS RETEST SPECIMENS

1 BLOCK = APPROX 2 IN.

PANEL NO. 5A WEDGE SECTION

16 FLEXURE SPECIMENS

1 IN. X 4 IN.
NOS 23 TO 38



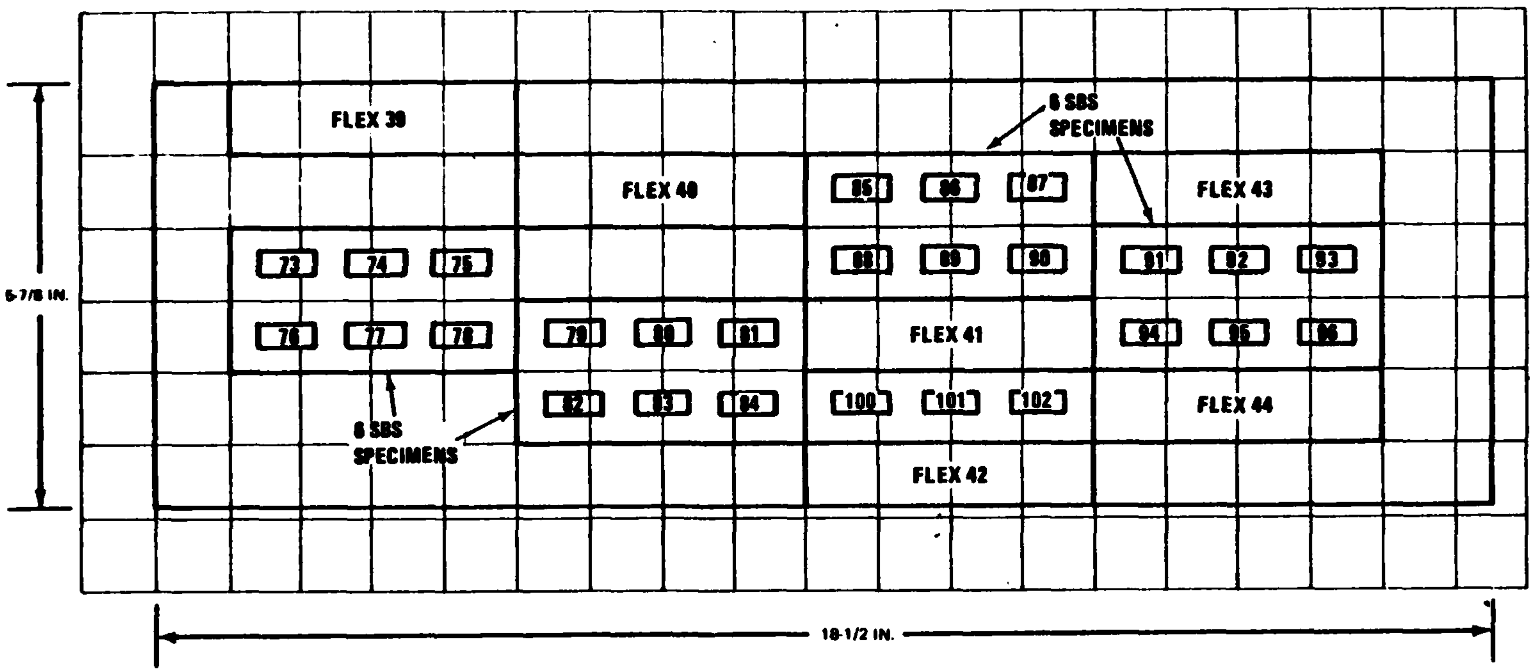
24 SHORT BEAM SHEAR (SBS)
0.25 IN. X 9t
NOS. 49 TO 72
t - THICKNESS

97, 98, 99 } SBS RETEST SPECIMENS

1 BLOCK = APPROX. 2 IN.

PANEL NO. 3A WEDGE SECTION
6 FLEXURE SPECIMENS

1 IN. X 4 IN.
NOS. 39 TO 44



24 SHORT BEAM SHEAR (SBS)
0.25 IN. X 9 t
NOS. 73 TO 96
t - THICKNESS

100, 101, 102 } SBS RETEST SPECIMENS

1 BLOCK = APPROX 1 IN.

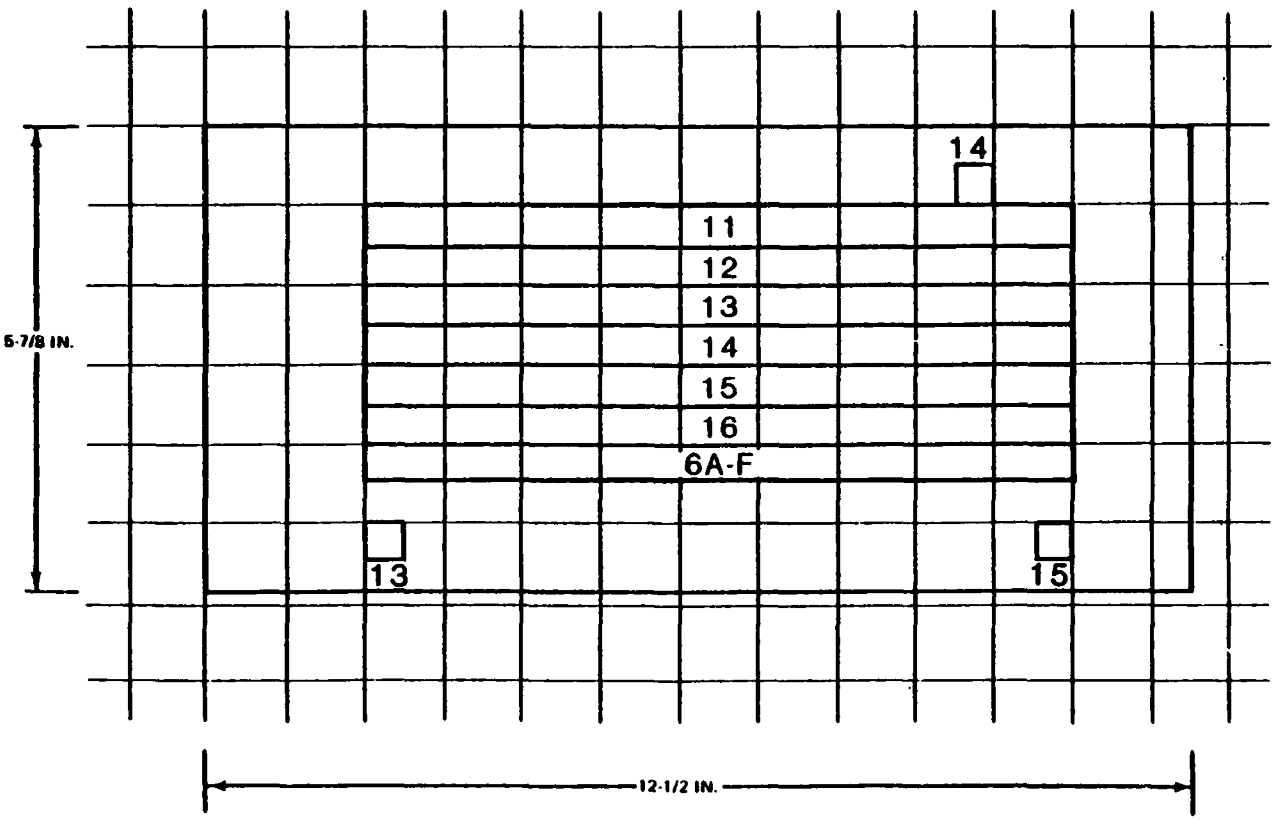
PANEL NO. 2A WEDGE SECTION

6 TENSILE SPECIMENS

1 FATIGUE SPECIMEN

1/2 IN. X 9 IN.

NOS 19 TO 24



☐ — RESIN CONTENT SPECIMEN

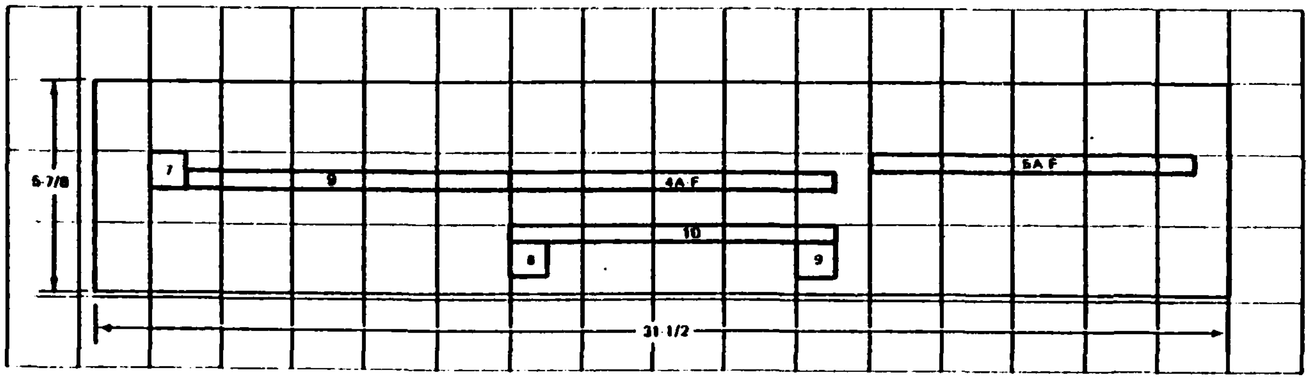
1 BLOCK = APPROX 1 IN.

PANEL NO. 4A WEDGE SECTION

2 TENSILE SPECIMENS

2 FATIGUE SPECIMENS

1/2 IN. X 9 IN.
NOS 9 AND 10

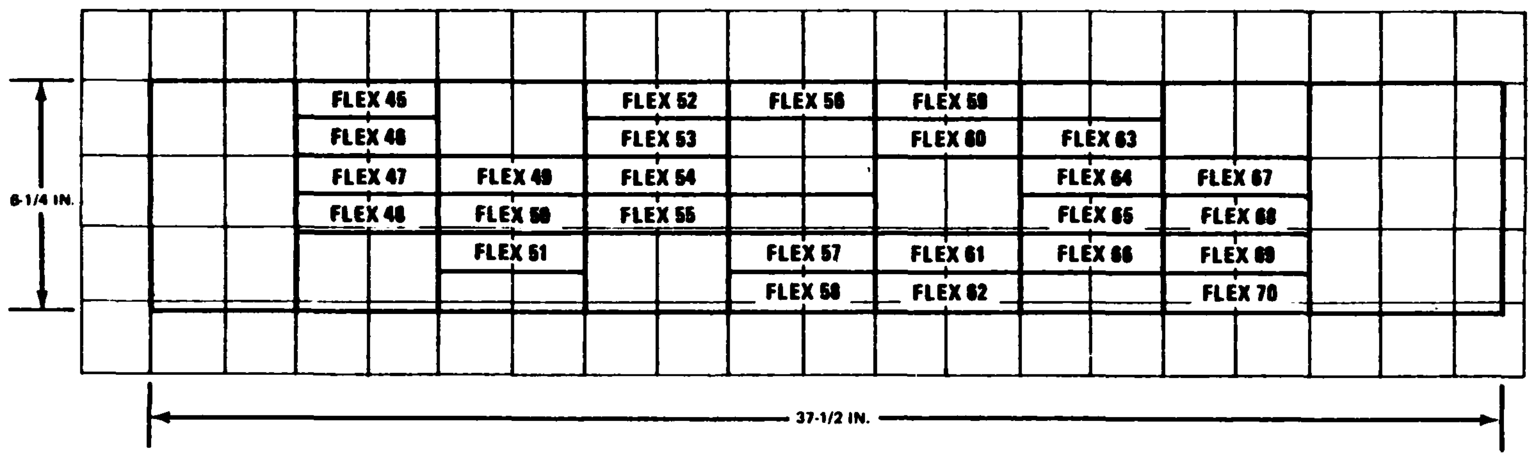


1 BLOCK = APPROX 2 IN.

☐ RESIN CONTENT SPECIMEN

PANEL NO. 1 CONSTANT THICKNESS SECTION
26 FLEXURE SPECIMENS

1 IN. X 4 IN.
NOS 45 TO 70



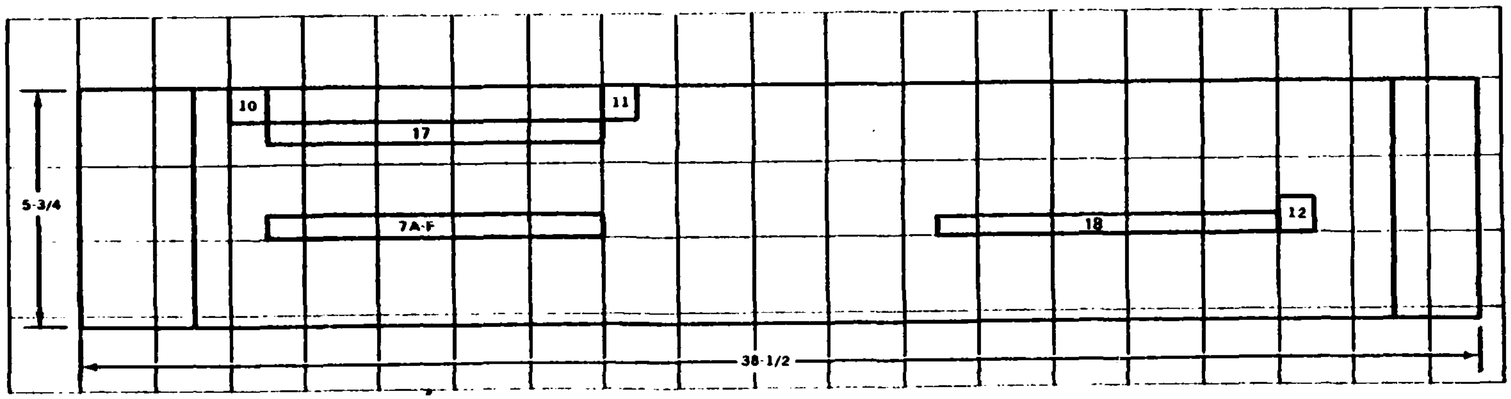
1 BLOCK = APPROX 2 IN.

PANEL NO. 2 CONSTANT THICKNESS SECTION

2 TENSILE SPECIMENS

1 FATIGUE SPECIMEN

1/2 IN. X 9 IN.
NOS 17 AND 18



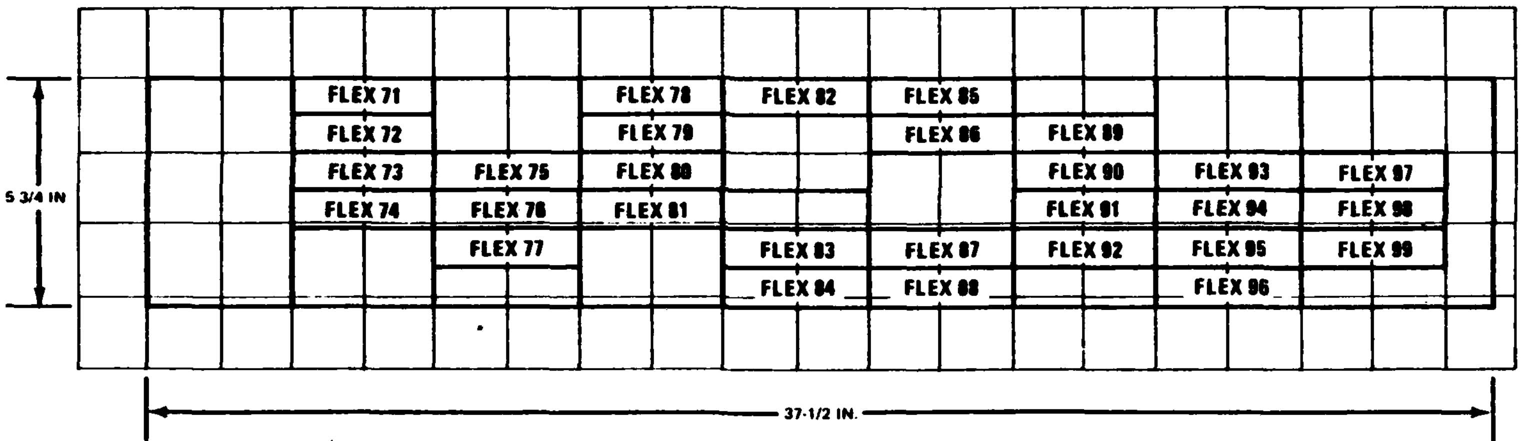
1 BLOCK =APPROX 2 IN.

☐ RESIN CONTENT SPECIMEN

PANEL NO. 3 CONSTANT THICKNESS SECTION

26 FLEXURE SPECIMENS

1 IN. X 4 IN.
NOS 71 TO 96



97
98 } RETEST SPECIMENS
99

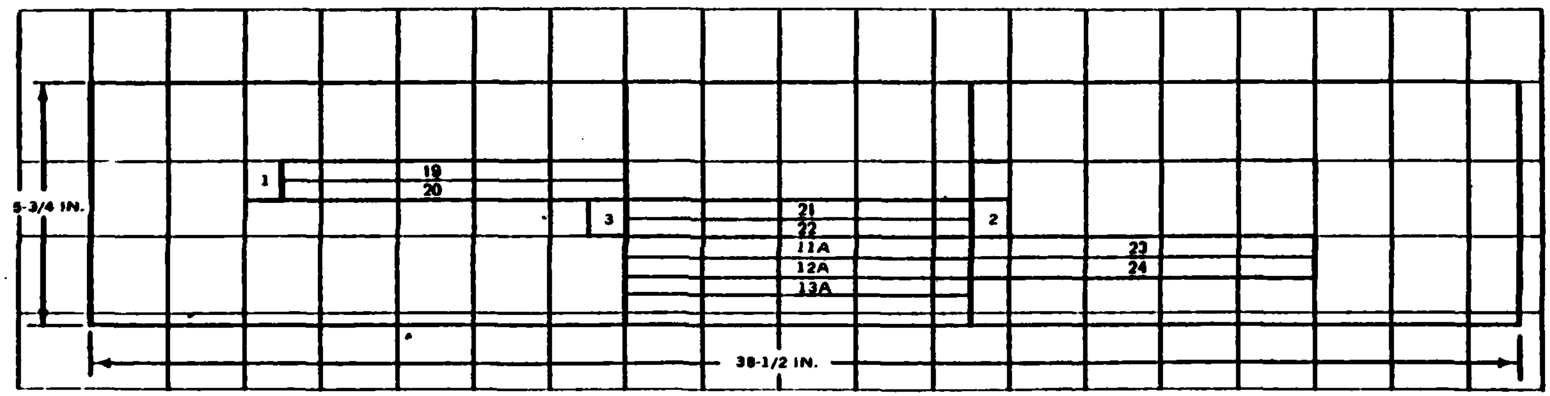
1 BLOCK = APPROX 2 IN.

PANEL NO. 4 CONSTANT THICKNESS SECTION

6 TENSILE SPECIMENS

1 FATIGUE SPECIMEN

1/2 IN. X 9 IN.
NOS 19 TO 24



☐ RESIN CONTENT SPECIMEN

1 BLOCK - APPROX 2 IN.

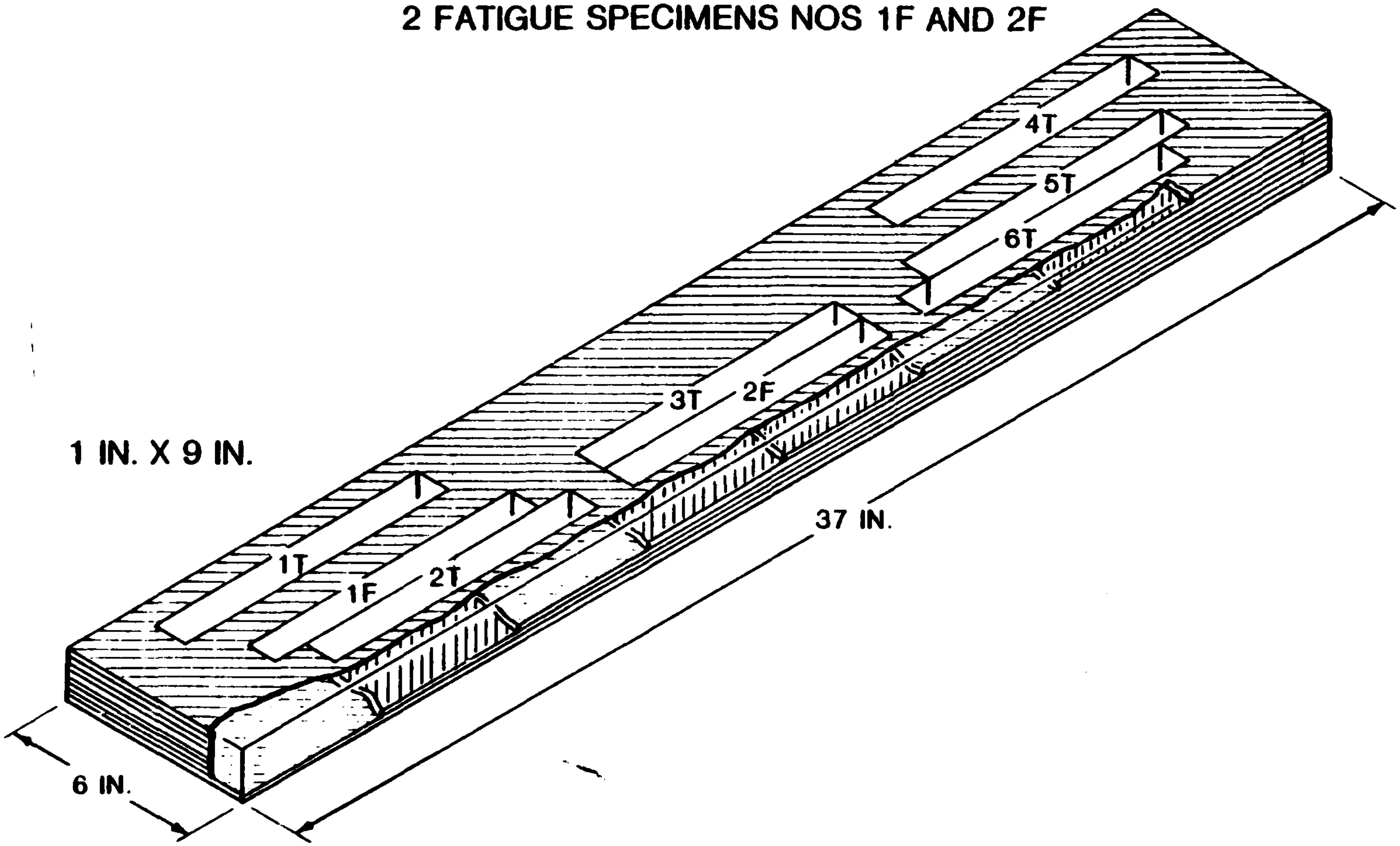
11A, 12A, 13A — RETEST SPECIMENS

± 45° FIBER ORIENTATION 8 PLY

PANEL NO. 2 CONSTANT THICKNESS SECTION

6 TENSILE SPECIMENS NOS 1T TO 6T

2 FATIGUE SPECIMENS NOS 1F AND 2F



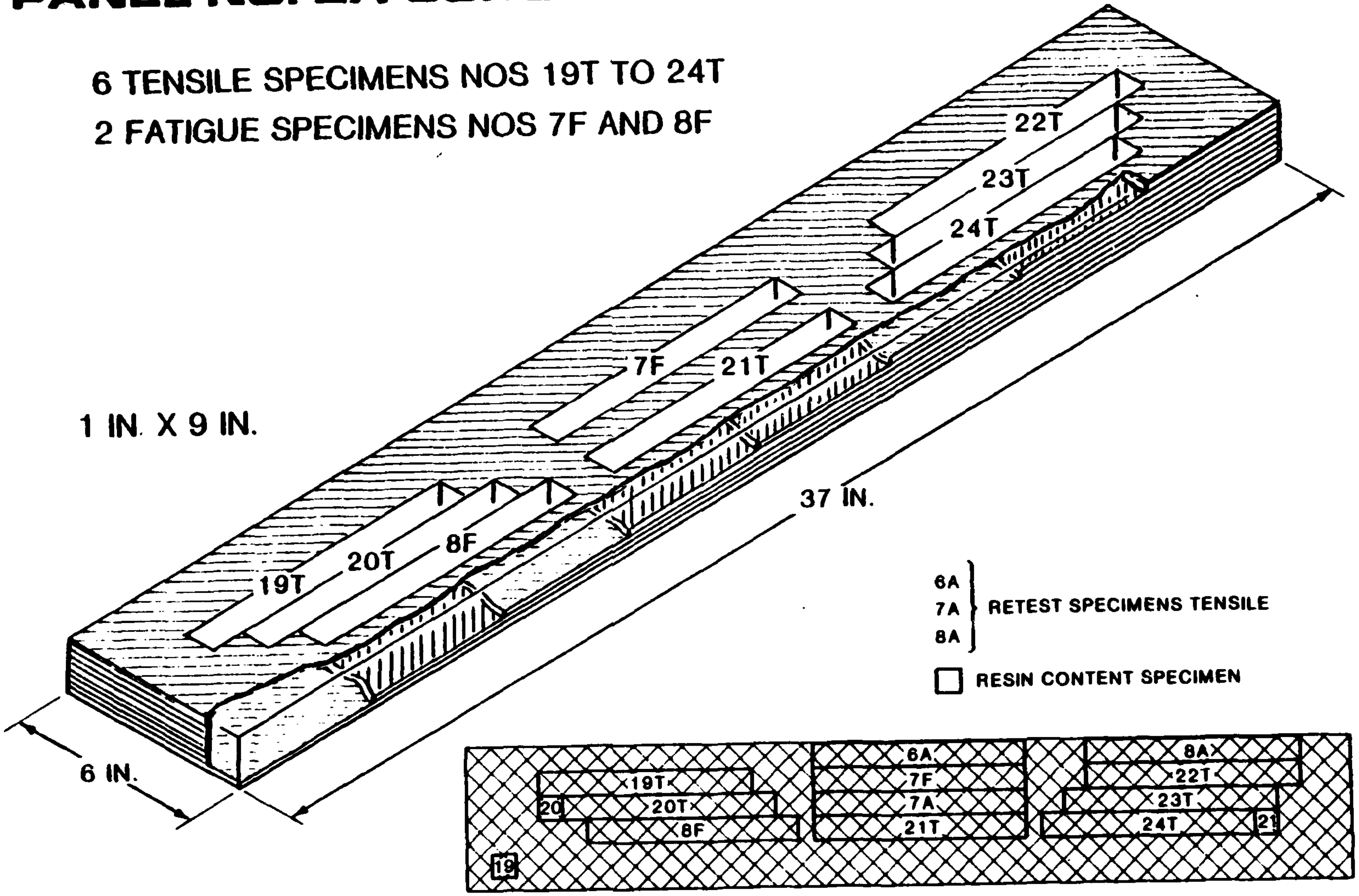
± 45° FIBER ORIENTATION 8 PLY

PANEL NO. 2A CONSTANT THICKNESS SECTION

6 TENSILE SPECIMENS NOS 19T TO 24T

2 FATIGUE SPECIMENS NOS 7F AND 8F

1 IN. X 9 IN.



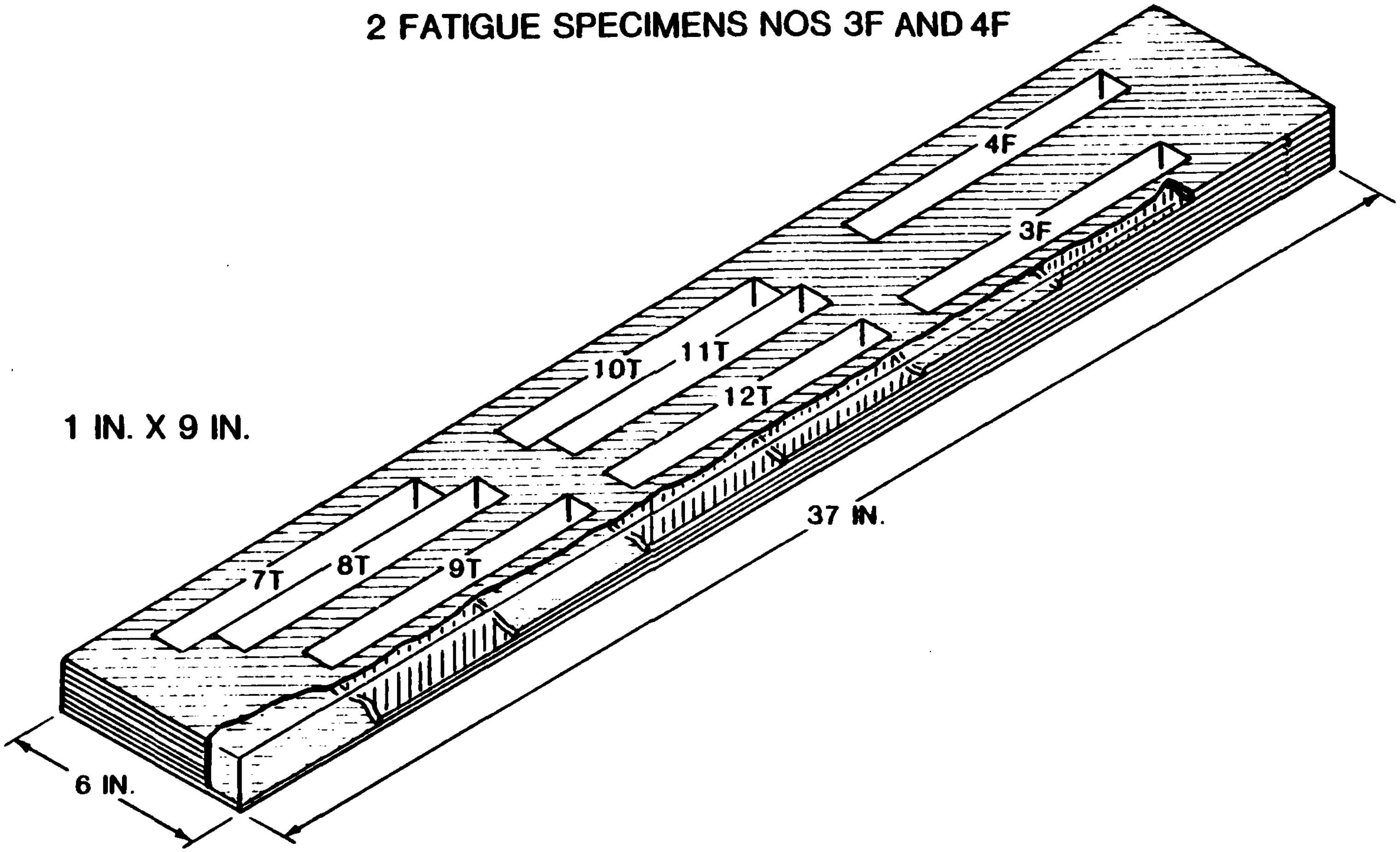
± 45° FIBER ORIENTATION 8 PLY

PANEL NO. 4 CONSTANT THICKNESS SECTION

6 TENSILE SPECIMENS NOS 7T TO 12T

2 FATIGUE SPECIMENS NOS 3F AND 4F

1 IN. X 9 IN.



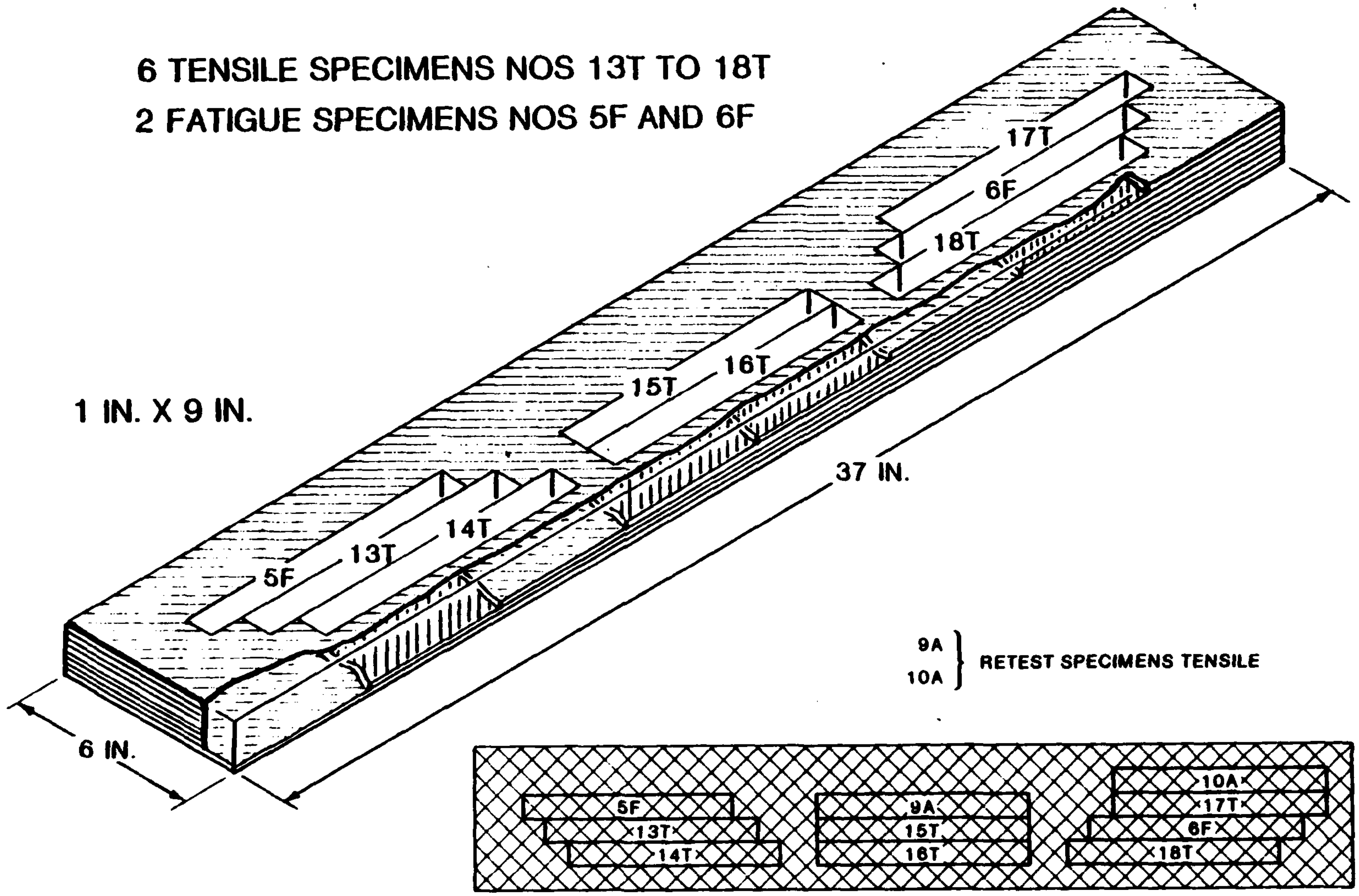
± 45° FIBER ORIENTATION 8 PLY

PANEL NO. 4A CONSTANT THICKNESS SECTION

6 TENSILE SPECIMENS NOS 13T TO 18T

2 FATIGUE SPECIMENS NOS 5F AND 6F

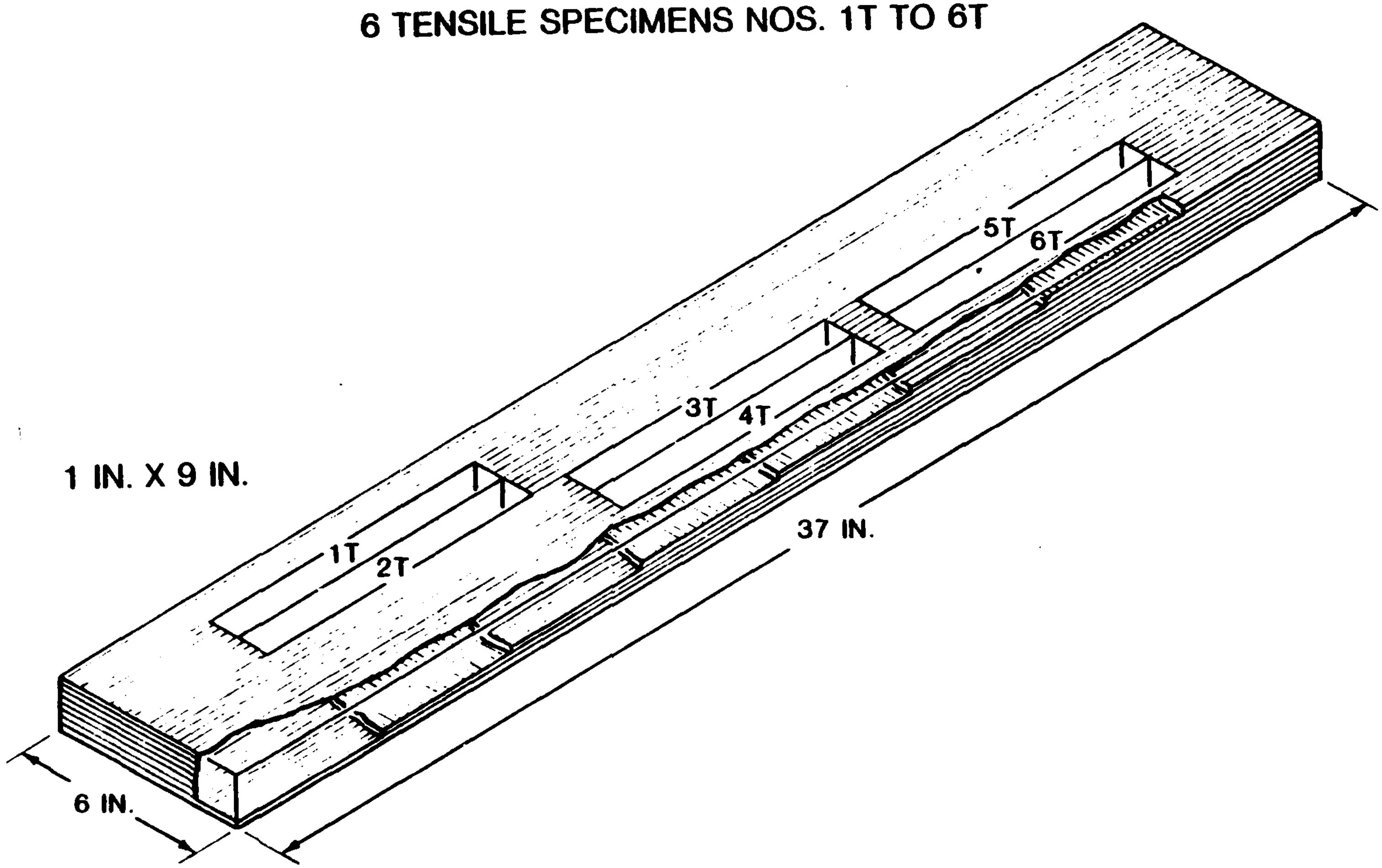
1 IN. X 9 IN.



0/90° FIBER ORIENTATION — 8 PLY

PANEL NO. 2 CONSTANT THICKNESS SECTION

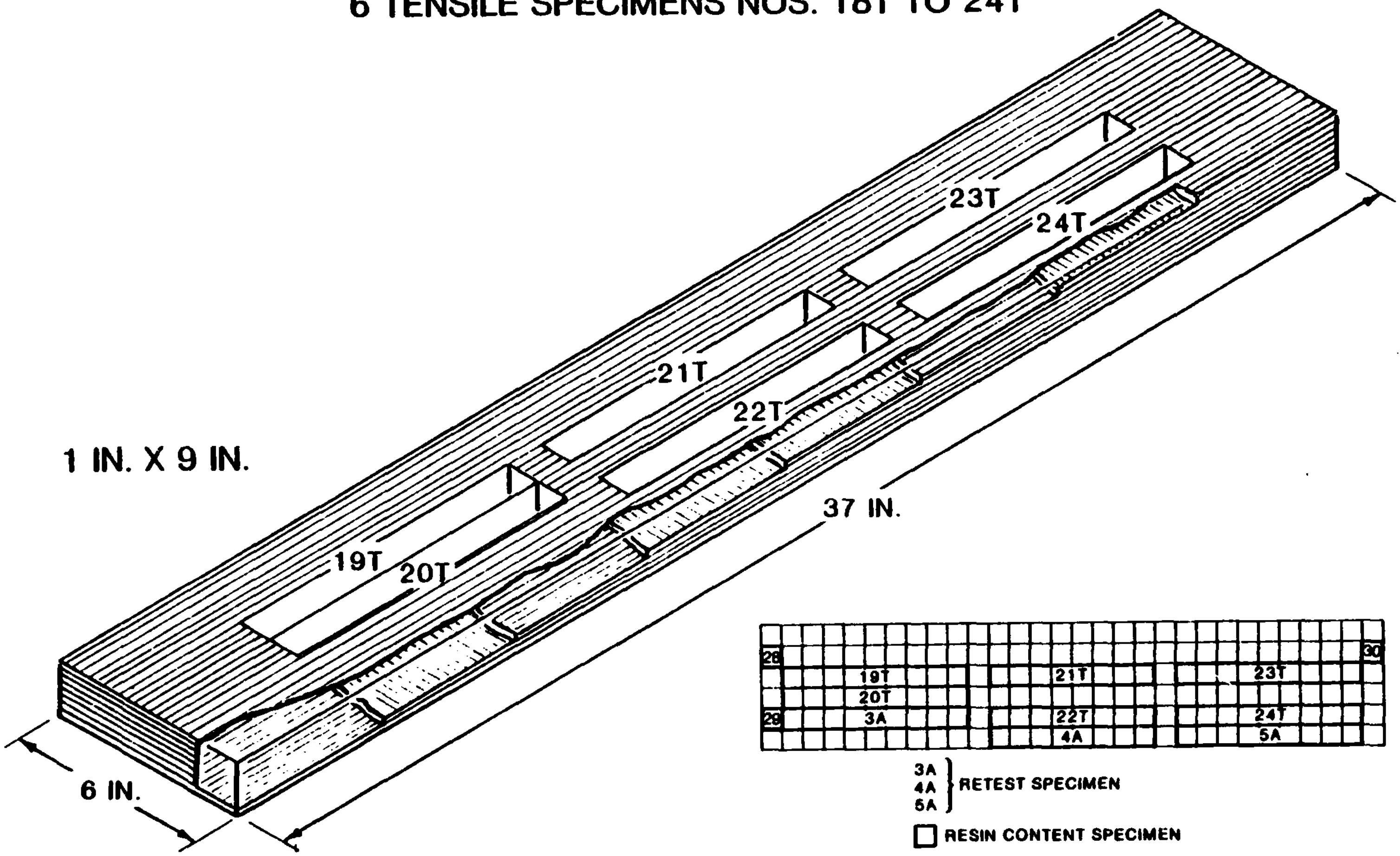
6 TENSILE SPECIMENS NOS. 1T TO 6T



0/90° FIBER ORIENTATION — 8 PLY

PANEL NO. 2A CONSTANT THICKNESS SECTION

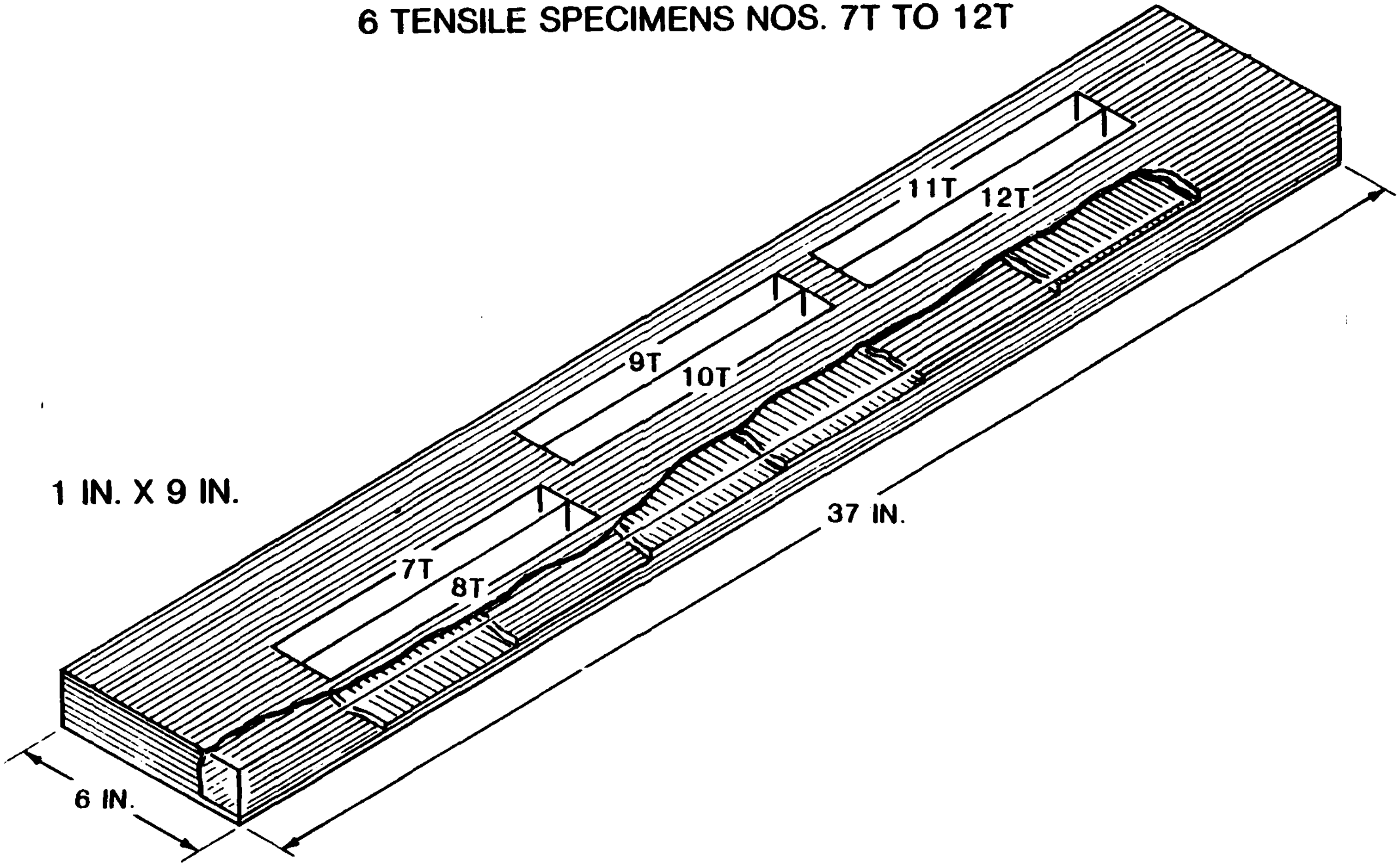
6 TENSILE SPECIMENS NOS. 18T TO 24T



0/90° FIBER ORIENTATION — 8 PLY

PANEL NO. 4 CONSTANT THICKNESS SECTION

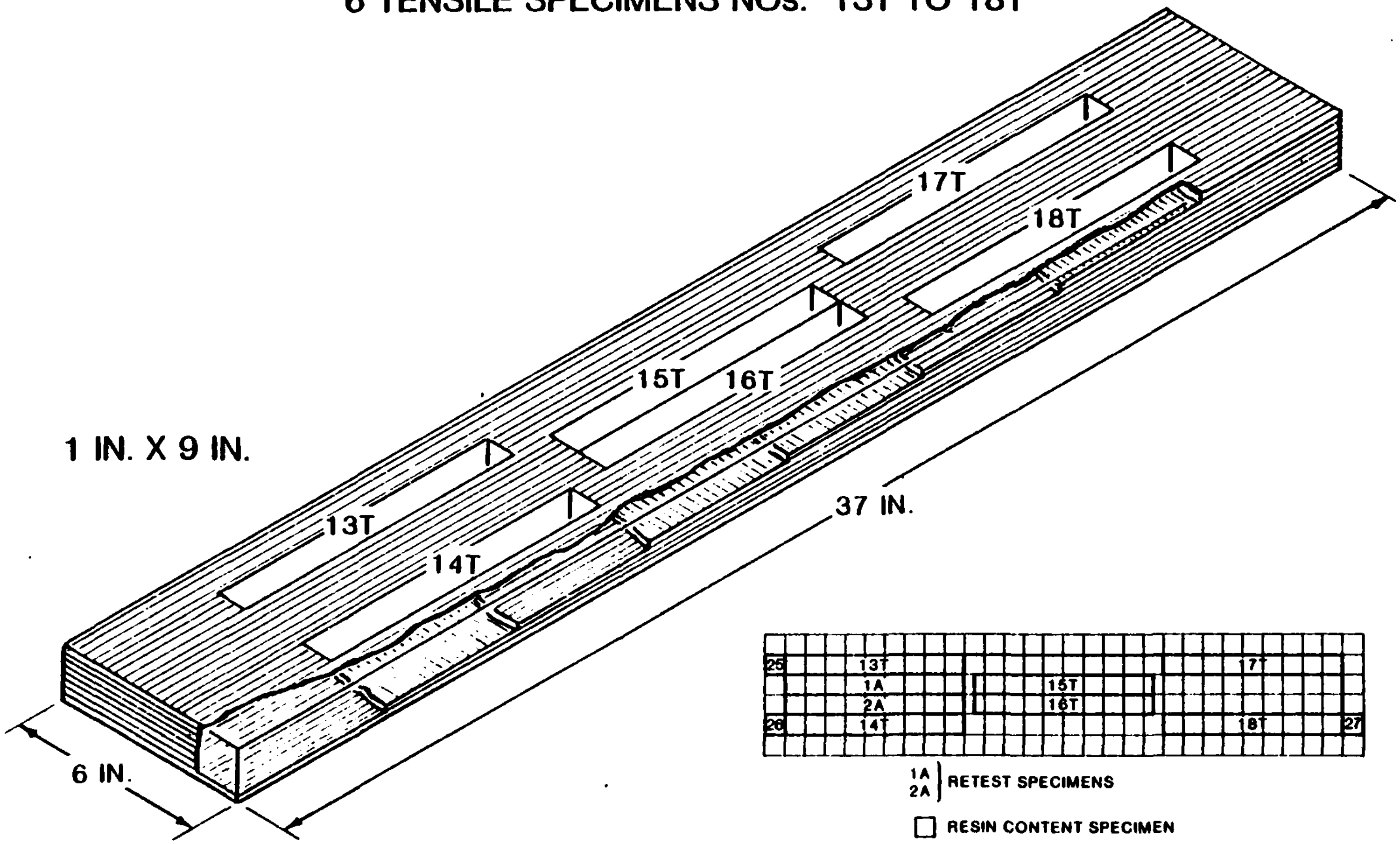
6 TENSILE SPECIMENS NOS. 7T TO 12T



0/90° FIBER ORIENTATION — 8 PLY

PANEL NO. 4A CONSTANT THICKNESS SECTION

6 TENSILE SPECIMENS NOs. 13T TO 18T



AD-A089 728   BOEING VERTOL CO PHILADELPHIA PA   F/G 13/8

CONVEYORIZED RADIO FREQUENCY CURE OF EPOXY GLASS COMPOSITES.(U)

MAY 80 L C RITTER   DAAG46-79-C-0009

UNCLASSIFIED   USAAVRADCOM-TR-80-F-16   NL

3 of 4

AD A 089728

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3 OF 4

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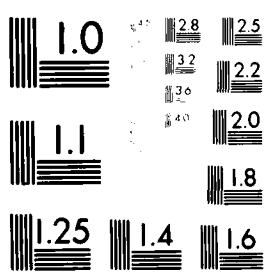
089728



MICROCOPY RESOLUTION TEST CHART

APPENDIX H

INITIAL TEST REPORT ON FLEXURAL AND SHORT BEAM SHEAR TESTS BY TESTING LABORATORY

COPY

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH CONTROL

DATE: 8-16-79

CUSTOMER: Boeing Vertol Co.

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A

PRE CONDITIONING: 30 min. @ 180°F

TEST CONDITION: 180°F

SPAN (L) 1.65 L6d RATIO: 15/1

SUPPORT RADIUS: 1/8 in.

NOSE RADIUS: 1/8 in.

TEST SPEED: 0.05 in./min

SPECIMEN LENGTH: 4 in.

Flexural Strength (S) = $\frac{3PL}{2bd^2}$ 2.475

Modulus of Elasticity (E_B) = $\frac{L^3m}{4bd^3}$ 1.123

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lb

b = Specimen width in inches

d = Depth of beam in inches

L = Span in inches

m = Initial slope of load-deflection curve in lb/in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lb)	m (Lb/in.)	E_B (PSI x 10^6)
58	135,000	0.110	1.000	660	5,797	4.89
72	122,710	0.113	0.992	628	5,217	4.09
78	99,030	0.119	1.006	570	4,918	3.26
80	132,260	0.112	1.007	675	5,530	4.39
82	130,490	0.112	1.004	664	5,505	4.38
85	125,620	0.109	0.995	600	5,042	4.39
92	132,860	0.108	1.003	628	5,021	4.46
94	128,820	0.110	0.994	626	5,405	4.59
AVG	125,850	0.112				4.31

Test Technician: J. Myers Approved: D.B.

COPY

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR CONTROL

DATE: 8-16-79

CUSTOMER: Boeing Vertol Co.

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A

PRE CONDITIONING: 40 hrs/23°C/50% RH

TEST CONDITION: 23°C/50% RH

SPECIMEN SIZE: 1/4 in. x 7/8 in.

SPAN: 0.490 in.

TEST SPEED: 0.05 in./min

L/D RATIO: 5/1

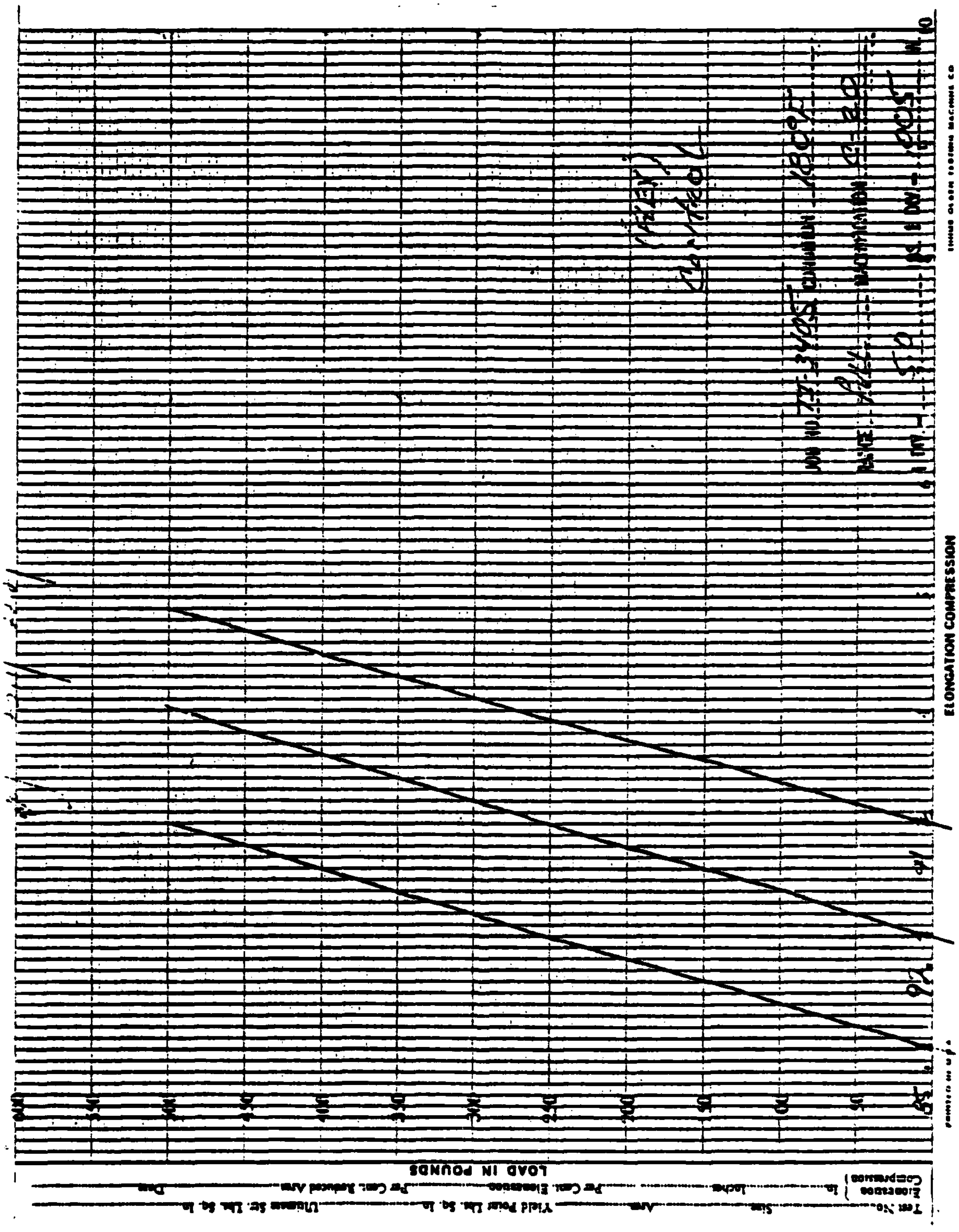
LOAD POINTS RADIUS:
Nose 1/8 in.
Supports 1/16 in.

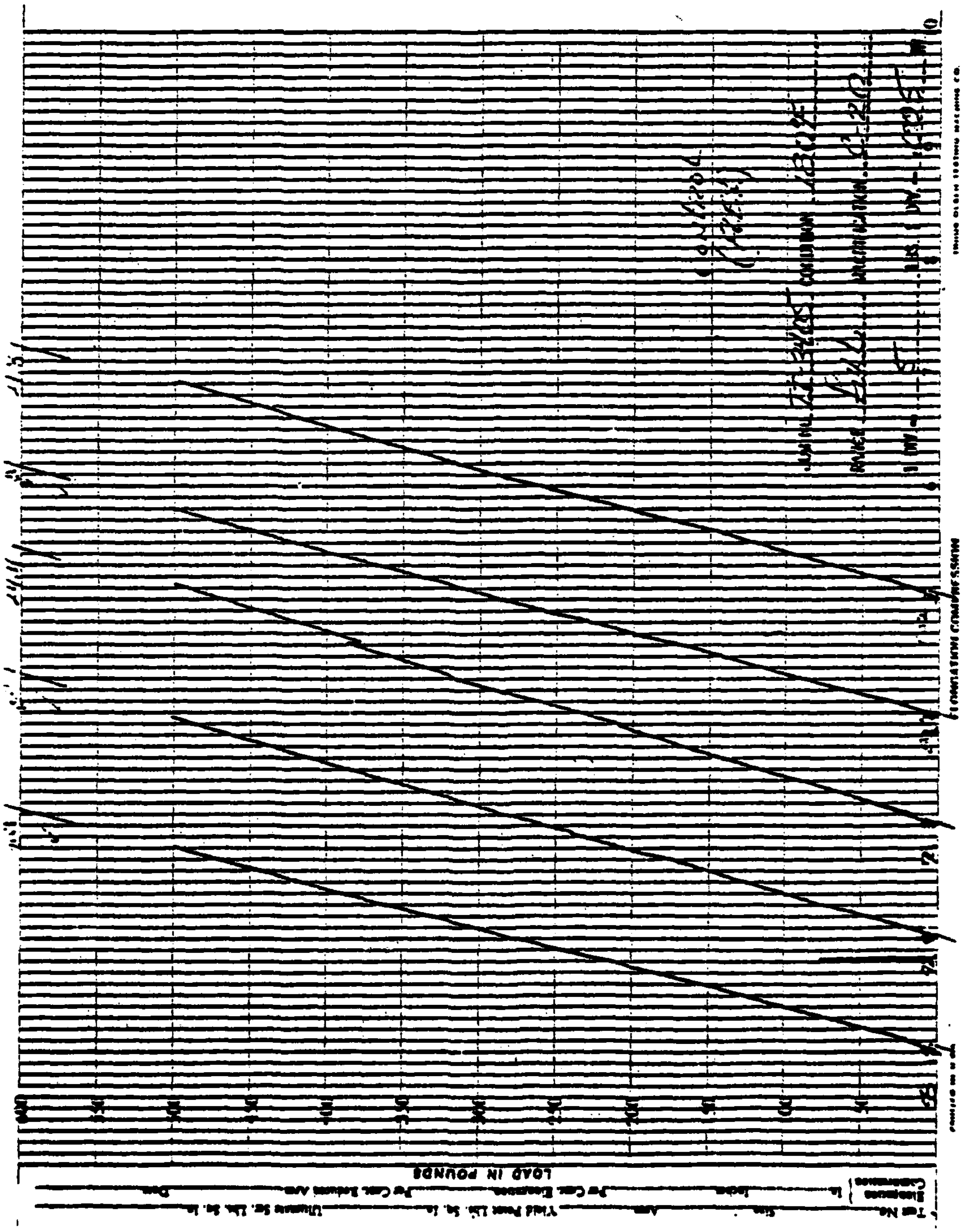
$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lb) P	Shear Strength S (PSI)
6	0.100	0.251	307.5	9,190
12	0.095	0.251	269.0	8,460
27	0.092	0.252	302.0	9,770
47	0.096	0.248	309.5	9,750
64	0.102	0.249	326.5	9,640
71	0.108	0.251	287.0	7,940
79	0.094	0.250	271.0	8,650
81	0.093	0.251	268.5	8,630
AVG	0.098			9,000

Test Technician: J. Myers

Approved: D.B.


ELONGATION COMPRESSION
LOAD IN POUNDS


LOAD IN POUNDS
ELONGATION IN COMPRESSION

COPY

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH CONTROL

DATE: 8-16-79

CUSTOMER: Boeing Vertol Co.

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A

PRE CONDITIONING: 40 hrs/23°C/50% RH

TEST CONDITION: 23°C/50% RH

SPAN (L) 1.65 L/d RATIO: 18/1

SUPPORT RADIUS: 1/8 in.

NOSE RADIUS: 1/8 in.

TEST SPEED: 0.05 in./min

SPECIMEN LENGTH: 4 in.

Flexural Strength (S) = $\frac{3PL}{2bd^2}$ 2.475

Modulus of Elasticity (E_B) = $\frac{L^3 m}{4bd^3}$ 1.1.23

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lb

b = Specimen width in inches

d = Depth of beam in inches

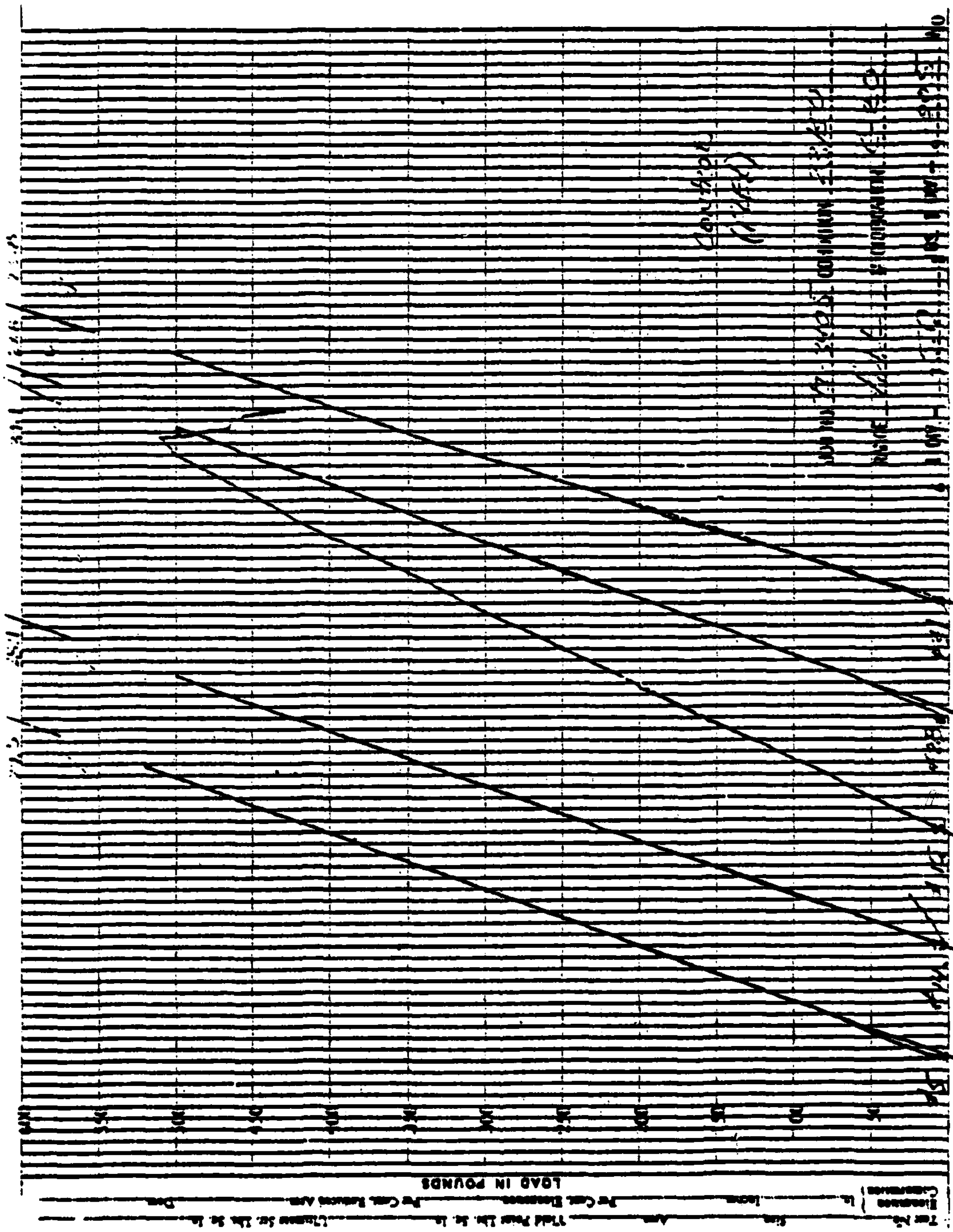
L = Span in inches

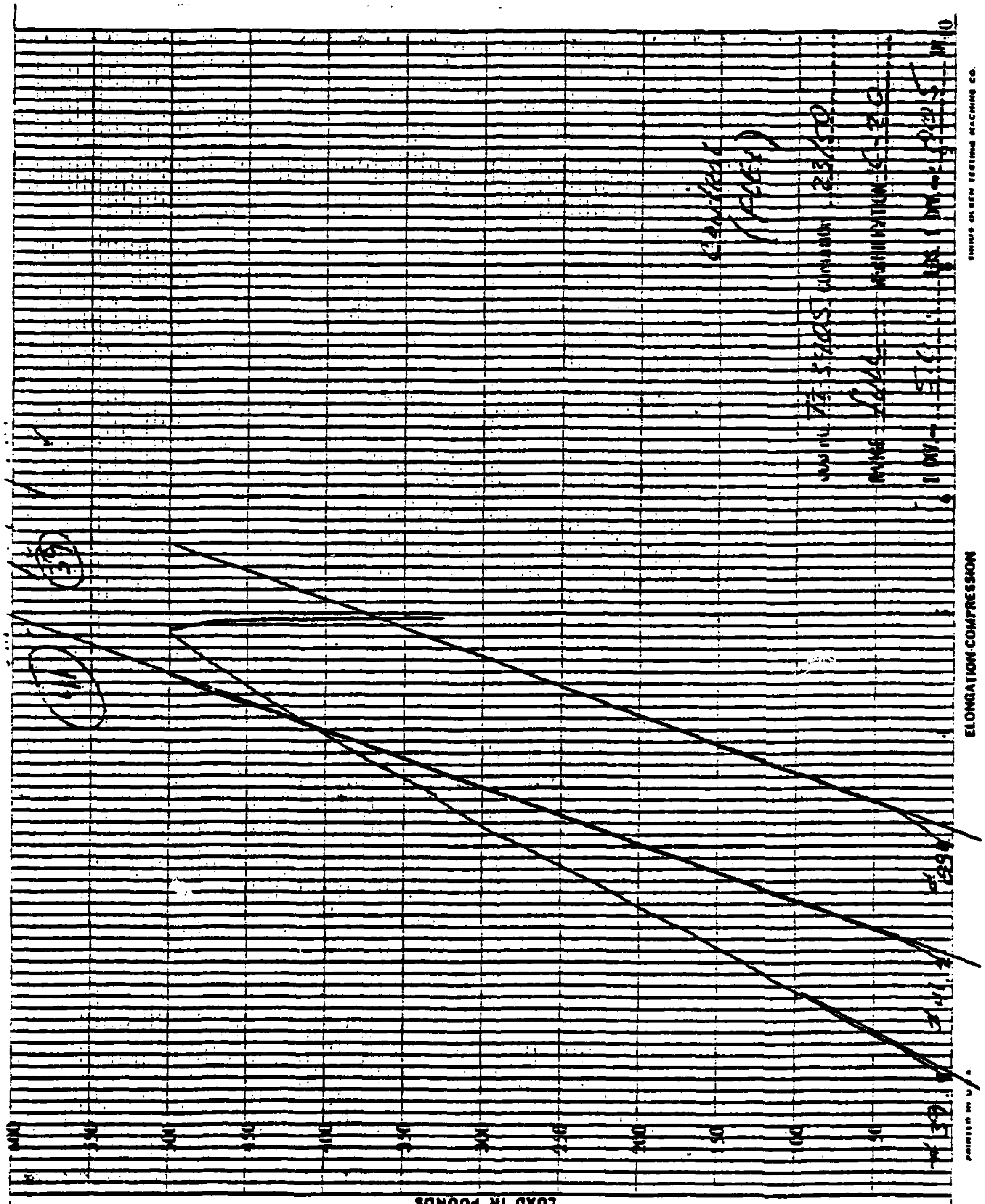
m = Initial slope of load-deflection curve in lb/in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lb)	m (Lb/in.)	E_B (PSI x 10^6)
5	192,620	0.095	1.008	708	4,068	5.29
14	195,120	0.097	1.003	744	4,181	5.13
15	169,980	0.086	1.008	512	3,069	5.38
28	176,320	0.096	0.987	648	4,027	5.18
34	158,270	0.102	0.986	656	4,651	4.99
39	170,600	0.085	1.004	500	2,765	5.04
41	198,250	0.094	0.989	700	4,123	5.64
88	183,100	0.095	0.996	665	4,040	5.31
AVG	180,530	0.094				5.25

Test Technician: J. Myers

Approved: D.B.


LOAD IN POUNDS
ELONGATION COMPRESSION


LOAD IN POUNDS
ELONGATION-COMPRESSION
600
550
500
450
400
350
300
250
200
150
100
50

APPENDIX I

PREPREG PROPERTIES

VOLATILE CONTENT

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.1

TEMP. OF OVEN: 325° F TIME IN OVEN: 10 minutes

SPECIMEN SIZE: 4" x 6"

TEST CONDITION: 23° C/50% R.H.

RESULTS

Spec. (No.)	Original Weight (gms.)	Wt. After Cond. (gms.)	Weight Loss (gms.)	Volatile (%)
1	6.3888	6.3690	.0198	.31
2	6.3605	6.3400	.0205	.32
3	6.4790	6.4485	.0305	.47
			AVERAGE	.37

Test Technician: T Burns Approved: D. Browning
T. Burns D. Browning

PREPREG RESIN CONTENT

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.2

TEMP. OF FURNACE: 1050° F TIME IN FURNACE: 30 minutes

SPECIMEN SIZE: 4" x 6"

TEST CONDITION: 23° C/50% R.H.

RESULTS

Spec. (No.)	Original Weight (gms.)	Wt.,Volatiles Removed (gms.)	Wt. After Ignition (gms.)	Loss in Wt. (gms.)	Resin Content (%)
1	6.3888	6.3690	4.4000	1.9690	30.8
2	6.3605	6.3400	4.3240	2.0160	31.7
3	6.4790	6.4485	4.4282	2.0203	31.2
			AVERAGE		31.2

Test Technician: T. Burns
T. Burns

Approved: D. Browning
D. Browning

PREPREG PLY THICKNESS

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.1

SPECIMEN SIZE: 4" x 6"

TEST CONDITION: 23° C/50% R.H.

RESULTS

Specimen (No.)		Thickness (Mils)
1		10.0
2		9.5
3		9.4
	AVERAGE	9.6

Test Technician: T. Burns
T. Burns

Approved: D. Browning
D. Browning

GLASS BASIC WEIGHT

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.2

SPECIMEN SIZE: 4" x 6" (Resin content specimens)

TEST CONDITION: 23° C/50% R.H.

RESULTS

Specimen (No.)	WEIGHT (gms.)		BASIC GLASS WT. ($gms./ft^2$)
1	4.4000		26.40
2	4.3240		25.94
3	4.4282		26.57
		AVERAGE	26.30

Test Technician: T. Burns
T. Burns

Approved: D. Browning
D. Browning

TOTAL WEIGHT

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.1

SPECIMEN SIZE: 4" x 6"

TEST CONDITION: 23° C/50% R.H.

RESULTS

Specimen (No.)	WEIGHT (gms.)	PREPREG TOTAL WEIGHT (gms./ft^2)
1	6.3888	38.33
2	6.3605	38.16
3	6.4790	38.87
	AVERAGE	38.45

Test Technician: T. Burns
T. Burns

Approved: D. Browning
D. Browning

GEL TIME

DATE: January 22, 1980

CUSTOMER:	Boeing Vertol Company
MATERIAL:	SP250-E-33 W-456, Lot 7, Jumbo 50
SPECIFICATION:	BMS 8-196A, Paragraph 8.6
TEMP. OF PLATEN:	200° F.
SPECIMEN SIZE:	1" x 6"

RESULTS

Could not remove enough resin from sample to determine Gel Time.

Test Technician: T. Burns
T. Burns

Approved: D. Browning
D. Browning

RESIN FLOW

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.5

TEMP. OF PRESS: 250° F Applied Pressure: 15 PSI

SPECIMEN SIZE: 4" x 4" Time in Press: 20 minutes

TEST CONDITION: 23° C/50% R.H.

RESULTS

Specimen (No.)	Original Weight (gms.)	Final Wt. (gms.)	Loss in Weight (gms.)	Resin Flow (%)
1	16.7661	15.8568	.9093	5.42
2	16.8378	15.8920	.9458	5.62
			AVERAGE	5.52

Test Technician: T Burns Approved: D. Browning

T. Burns D. Browning

APPENDIX J

PRESS CURED LAMINATE PHYSICAL PROPERTIES

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

VOID CONTENT

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.3

LAMINATE: 5 Ply and 12 Ply

Void Content (%) V/O = 100-Fiber Content-Resin Volume

RESULTS

Specimen (No.)	Fiber Content (%)	Resin Volume (%)	Void Content (%)
5 ply 1	58.0	41.8	0.2
5 ply 2	57.8	40.6	1.6
5 ply 3	60.5	39.4	0.1
	AVERAGE		0.6
12 ply 1	50.0	46.6	3.4
12 ply 2	51.2	43.8	5.0
12 ply 3	50.4	46.3	3.3
	AVERAGE		3.9

Test Technician: T. Burns
T. Burns

Approved: D. Browning
D. Browning

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FIBER CONTENT

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.3

LAMINATE: 5 ply and 12 ply Fiber Content(%) V/O = $\frac{wg}{dg} \times \frac{DS}{WS} \times 100$

RESULTS

Spec. (No.)	WG Glass Wt. (gms.)	DG Density Glass (gms/CM^3)	DS Density Sample (gms/CM^3)	WS Sample Wt. (gms.)	Fiber Content (%)
5 ply 1	2.3283	2.52	1.985	3.1602	58.0
5 ply 2	2.1979	2.52	1.965	2.9634	57.8
5 ply 3	2.3176	2.52	2.018	3.0652	60.5
			AVERAGE		58.8
12 ply 1	2.0872	2.52	1.841	3.0519	50.0
12 ply 2	2.1953	2.52	1.838	3.1273	51.2
12 ply 3	2.0860	2.52	1.848	3.0358	50.4
			AVERAGE		50.5

Test Technician: T Burns
T. Burns

Approved: D. Browning
D. Browning

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

RESIN VOLUME

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.3

LAMINATE: 5 ply and 12 ply Resin Volume(%) $\frac{WR}{DR} \times \frac{DS}{WS} \times 100$

RESULTS

Spec. (No.)	Resin Wt. (gms.)	DR Density Resin (gms/CM^3)	DS Density Sample (gms/CM^3)	Ws Wt. of Sample (gms.)	Resin Volume (%)
5 ply 1	.8319	1.25	1.985	3.1602	41.8
5 ply 2	.7655	1.25	1.965	2.9634	40.6
5 ply 3	.7476	1.25	2.018	3.0652	39.4
			AVERAGE		40.6
12 ply 1	.9647	1.25	1.841	3.0519	46.6
12 ply 2	.9320	1.25	1.838	3.1273	43.8
12 ply 3	.9498	1.25	1.848	3.0358	46.3
			AVERAGE		45.6

Test Technician: T. Burns
T. Burns

Approved: D. Browning
D. Browning

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

COMPOSITE DENSITY

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.3

SPECIMEN SIZE: 1 1/2" x 1 1/2" (5 ply)

TEST CONDITION: 23° C Weight of Wire (W): .8055 (gms.)

RESULTS

Spec. (No.)	Dry Wt. (gms)(a)	Wt.(gms.) in H_2O(b)+W	SP Gravity $\left(\frac{a}{a-b}\right)$	Density (gms./CM^3)	(Lbs/in^3)
1	3.1646	2.3800	1.990	1.985	.072
2	2.9685	2.2672	1.970	1.965	.071
3	3.0694	2.3575	2.023	2.018	.073
		AVERAGE	1.994	1.989	.072

Test Technician: T. Burns T. Burns Approved: D. Browning D. Browning

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

COMPOSITE DENSITY

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.3

SPECIMEN SIZE: 1" x 1" (12 ply)

TEST CONDITION: 23° C Weight of Wire (W): .8086 (gms.)

RESULTS

Spec. (No.)	Dry Wt. (gms)(a)	Wt. (gms.) in H_2O(b)+W	SP.Gravity $\left(\frac{a}{a-b}\right)$	Density (gms/Cm^3)	(Lbs/in^3)
1	3.0550	2.2085	1.846	1.841	.067
2	3.1300	2.2400	1.843	1.838	.066
3	3.0394	2.2073	1.853	1.848	.067
		AVERAGE	1.847	1.842	.067

Test Technician: T. Burns
T. Burns

Approved: D. Browning
D. Browning

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

RESIN CONTENT

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.3

TEMP. OF FURNACE: 1050° F Time in Furnace: 60 minutes

SPECIMEN SIZE: 1 1/2" x 1 1/2" (5 ply) and 1" x 1" (12 ply)

$$\text{Resin Content (\%)}\ w/o = \frac{ws-wg}{ws} \times 100$$

Specimen (No.)	ws sample Weight (gms.)	wr Resin Weight (gms.)	wg Glass Weight (gms.)	Resin Content (%)
5 ply 1	3.1602	.8319	2.3283	26.3
5 ply 2	2.9634	.7655	2.1979	25.8
5 ply 3	3.0652	.7476	2.3176	24.4
			AVERAGE	25.5
12 ply 1	3.0519	.9647	2.0872	31.6
12 ply 2	3.1273	.9320	2.1953	29.8
12 ply 3	3.0358	.9498	2.0860	31.3
			AVERAGE	30.9

Test Technician: T. Burns
T. Burns

Approved: D. Browning
D. Browning

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

LAMINATE/PLY THICKNESS

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A, Paragraph 8.4

SPECIMEN SIZE: 3" x 12" (5 ply) 6" x 7 1/2" (12 ply)

TEST CONDITION: 23° C/50% R.H.

RESULTS

Reading (No.)	Laminate Thickness (Mils)		Ply Thickness (Mils)	
	12 ply	5 ply	12 ply	5 ply
1	102	54		
2	101	50		
3	113	43		
4	111	42		
5	110	44		
AVG.	107	47	8.9	9.4

Test Technician: T. Burns
T. Burns

Approved: D. Browning
D. Browning

APPENDIX K

ROCKWELL HARDNESS

CUSTOMER: Boeing Vertol Company Date: January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50(Panel No. 1 constant thick.)

Specification. ASTM D785-65

Pre-Conditioning: 40 hrs./23° C/50% R.H.

Test Condition: 23° C/50% R.H.

Specimen Size: 5 3/4" x 37 1/2"

Scale: M Penetrator: 1/4" ball Load: 100 Kg.

Specimen (No.)	Hardness Reading (H)	Thickness (in.)	No. of Pieces
1	98	.102	1
2	102	.094	1
3	100	.091	1
4	99	.096	1
5	87	.089	1
6	92	.092	1
7	99	.094	1
8	95	.096	1
9	87	.095	1
10	97	.101	1

Avg. H = 96

Respectfully Submitted

CINCINNATI TESTING LABORATORIES, INC.
417 NORTHLAND ROAD
CINCINNATI, OHIO 45240

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

CUSTOMER: Boeing Vertol Company Date: January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50 (Panel No. 2 constant thick.)

Specification: ASTM D785-65

Pre-Conditioning: 40 hrs./23° C/50% R.H.

Test Condition: 23° C/50% R.H.

Specimen Size: 5 3/4" x 38 1/2"

Scale: M Penetrator: 1/4" ball Load: 100 Kg.

Specimen (No.)	Hardness Reading (H)	Thickness (in.)	No. of Pieces
1	74	.045	1
2	74	.044	1
3	58	.046	1
4	64	.045	1
5	81	.044	1
6	72	.045	1
7	78	.045	1
8	82	.046	1
9	83	.045	1
10	76	.044	1

Avg. H = 74

Respectfully Submitted

CINCINNATI TESTING LABORATORIES, INC.
417 NORTHLAND ROAD
CINCINNATI, OHIO 45240

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

CUSTOMER:	Boeing Vertol Company	Date:	January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50 (Panel No. 3 constant thick.)

Specification: ASTM D785-65

Pre-Conditioning: 40 hrs./23° C/50% R.H.

Test Condition: 23° C/50% R.H.

Specimen Size: 5 3/4" x 37 1/2"

Scale: M   Penetrator: 1/4" ball   Load: 100 Kg.

Specimen (No.)	Hardness Reading (H)	Thickness (in.)	No. of Pieces
1	79	.096	1
2	78	.087	1
3	73	.103	1
4	61	.089	1
5	83	.094	1
6	84	.096	1
7	89	.091	1
8	78	.101	1
9	87	.094	1
10	78	.096	1

Avg. H = 79

Respectfully Submitted

CINCINNATI TESTING LABORATORIES, INC.
417 NORTHLAND ROAD
CINCINNATI, OHIO 45240

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

CUSTOMER: Boeing Vertol Company

Date: January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumb0 50 (Panel No. 4 constant thick.)

Specification: ASTM D785-65

Pre-Conditioning: 40 hrs./23° C/50% R.H.

Test Condition: 23° C/50% R.H.

Specimen Size: 5 3/4" x 38 1/2"

Scale: M

Penetrator: 1/4" ball

Load: 100 Kg.

Specimen (No.)	Hardness Reading (H)	Thickness (in.)	No. of Pieces
1	73	.045	1
2	71	.047	1
3	90	.045	1
4	79	.046	1
5	89	.044	1
6	83	.045	1
7	91	.045	1
8	90	.044	1
9	79	.046	1
10	89	.046	1

Avg. H = 83

Respectfully Submitted

CINCINNATI TESTING LABORATORIES, INC.

417 NORTHLAND ROAD
CINCINNATI, OHIO 45240

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

CUSTOMER: Boeing Vertol Company — Date: January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50 (Panel No. 2 wedge section)

Specification: ASTM D785-65

Pre-Conditioning: 40 hrs./23° C/50% R.H.

Test Condition: 23° C/50% R.H.

Specimen Size: 5 7/8" x 12 1/2"

Scale: M — Penetrator: 1/4" ball — Load: 100 Kg.

Specimen (No.)	Hardness Reading (H)	Thickness (in.)	No. of Pieces
1	95	.052	1
2	84	.051	1
3	76	.051	1
4	80	.052	1
5	85	.051	1
6	81	.050	1
7	83	.052	1
8	87	.052	1
9	79	.051	1
10	81	.051	1

Avg. H = 83

Respectfully Submitted

CINCINNATI TESTING LABORATORIES, INC.
417 NORTHLAND ROAD
CINCINNATI, OHIO 45240

Test Technician: R. Bushelman

Approved: D. Browning

CUSTOMER: Boeing Vertol Company Date: January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50 (Panel No. 2A wedge section)

Specification: ASTM D785-65

Pre-Conditioning: 40 hrs./23° C/50% R.H.

Test Condition: 23° C/50% R.H.

Specimen Size: 5 7/8" x 12 1/2"

Scale: M Penetrator: 1/4" ball Load: 100 Kg.

Specimen (No.)	Hardness Reading (H)	Thickness (in.)	No. of Pieces
1	64	.051	1
2	52	.052	1
3	62	.050	1
4	75	.051	1
5	83	.050	1
6	59	.051	1
7	81	.052	1
8	73	.051	1
9	76	.050	1
10	70	.051	1

Avg. H = 70

Respectfully Submitted

CINCINNATI TESTING LABORATORIES, INC.
417 NORTHLAND ROAD
CINCINNATI, OHIO 45240

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

CUSTOMER: Boeing Vertol Company Date: January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50 (Panel No. 3 wedge section)

Specification: ASTM D785-65

Pre-Conditioning: 40 hrs./23° C/50% R.H.

Test Condition: 23° C/50% R.H.

Specimen Size: 5 7/8" x 18 1/2"

Scale: M Penetrator: 1/4" ball Load: 100 Kg.

Specimen (No.)	Hardness Reading (H)	Thickness (in.)	No. of Pieces
1	96	.096	1
2	91	.091	1
3	94	.088	1
4	101	.094	1
5	104	.092	1
6	99	.104	1
7	98	.098	1
8	92	.092	1
9	97	.094	1
10	90	.089	1

Avg. H = 96

Respectfully Submitted

CINCINNATI TESTING LABORATORIES, INC.
417 NORTHLAND ROAD
CINCINNATI, OHIO 45240

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

ROCKWELL HARDNESS

CUSTOMER: Boeing Vertol Company Date: January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50 (Panel No. 3A wedge section)

Specification: ASTM D785-65

Pre-Conditioning. 40 hrs./23° C/50% R.H.

Test Condition: 23° C/50% R.H.

Specimen Size: 5 7/8" x 18 1/2"

Scale: M Penetrator: 1/4" ball Load: 100 Kg.

Specimen (No.)	Hardness Reading (H)	Thickness (in.)	No. of Pieces
1	92	.091	1
2	91	.096	1
3	101	.094	1
4	104	.102	1
5	103	.095	1
6	100	.088	1
7	99	.087	1
8	89	.093	1
9	94	.098	1
10	91	.102	1

Avg. H = 96

Respectfully Submitted

CINCINNATI TESTING LABORATORIES, INC.
417 NORTHLAND ROAD
CINCINNATI, OHIO 45240

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

CUSTOMER: Boeing Vertol Company Date: January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50 (Panel No. 4 wedge section)

Specification: ASTM D785-65

Pre-Conditioning: 40 hrs./23° C/50% R.H.

Test Condition: 23° C/50% R.H.

Specimen Size: 5 7/8" x 31 1/2"

Scale: M Penetrator: 1/4" ball Load: 100 Kg.

Specimen (No.)	Hardness Reading (H)	Thickness (in.)	No. of Pieces
1	72	.052	1
2	86	.051	1
3	76	.050	1
4	74	.050	1
5	85	.051	1
6	74	.050	1
7	87	.051	1
8	93	.052	1
9	92	.052	1
10	81	.051	1

Avg. H = 82

Respectfully Submitted

CINCINNATI TESTING LABORATORIES, INC.
417 NORTHLAND ROAD
CINCINNATI, OHIO 45240

Test Technician: R. Bushelman
R. Bushelman

Approved: D Browning
D. Browning

CUSTOMER:	Boeing Vertol Company	Date:	January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50 (Panel No. 4A wedge section)

Specification: ASTM D785-65

Pre-Conditioning: 40 hrs./23° C/50% R.H.

Test Condition: 23° C/50% R.H.

Specimen Size: 5 7/8" x 31 1/2"

Scale: M Penetrator: 1/4" ball Load: 100 Kg.

Specimen (No.)	Hardness Reading (H)	Thickness (in.)	No. of Pieces
1	92	.051	1
2	90	.050	1
3	82	.052	1
4	94	.052	1
5	89	.051	1
6	91	.050	1
7	85	.050	1
8	86	.052	1
9	94	.051	1
10	91	.051	1

Avg. H = 89

Respectfully Submitted

CINCINNATI TESTING LABORATORIES, INC.
417 NORTHLAND ROAD
CINCINNATI, OHIO 45240

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

CUSTOMER:	Boeing Vertol Company	Date:	January 22, 1980
Material:	SP250-E-33 W-456, Lot 7, Jumbo 50 (Panel No. 5 wedge section)		
Specification:	ASTM D785-65		
Pre-Conditioning:	40 hrs./23° C/50% R.H.		
Test Condition:	23° C/50% R.H.		
Specimen Size:	5 7/8" x 31 1/2"		

Scale: M Penetrator: 1/4" ball Load: 100 Kg.

Specimen (No.)	Hardness Reading (H)	Thickness (in.)	No. of Pieces
1	89	.098	1
2	100	.092	1
3	99	.093	1
4	104	.102	1
5	96	.089	1
6	98	.094	1
7	90	.096	1
8	105	.091	1
9	95	.089	1
10	92	.097	1

Avg. H = 97

Respectfully Submitted

CINCINNATI TESTING LABORATORIES, INC.
417 NORTHLAND ROAD
CINCINNATI, OHIO 45240

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

CUSTOMER: Boeing Vertol Company Date: January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50 (Panel No. 5A wedge section)

Specification: ASTM D785-65

Pre-Conditioning: 40 hrs./23° C/50% R.H.

Test Condition: 23° C/50% R.H.

Specimen Size: 5 7/8" x 31 1/2"

Scale: M Penetrator: 1/4" ball Load: 100 Kg.

Specimen (No.)	Hardness Reading (H)	Thickness (in.)	No. of Pieces
1	99	.089	1
2	93	.096	1
3	96	.103	1
4	100	.094	1
5	98	.092	1
6	80	.096	1
7	92	.087	1
8	99	.103	1
9	100	.095	1
10	98	.092	1

Avg. H = 96

Respectfully Submitted

CINCINNATI TESTING LABORATORIES, INC.
417 NORTHLAND ROAD
CINCINNATI, OHIO 45240

Test Technician: R. Bushelman

Approved: D. Browning

APPENDIX L

FATIGUE DATA

FATIGUE (±45°)

CUSTOMER: Boeing Vertol Company

Date: January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50

R Ratio: 0.10

Type Test: Tension-Tension

Pre-Conditioning: 40 hrs/23°C/50%RH

Frequency: 1800 CPM

Test Condition: 23°C/50% R.H.

Specimen Type: Figure 5

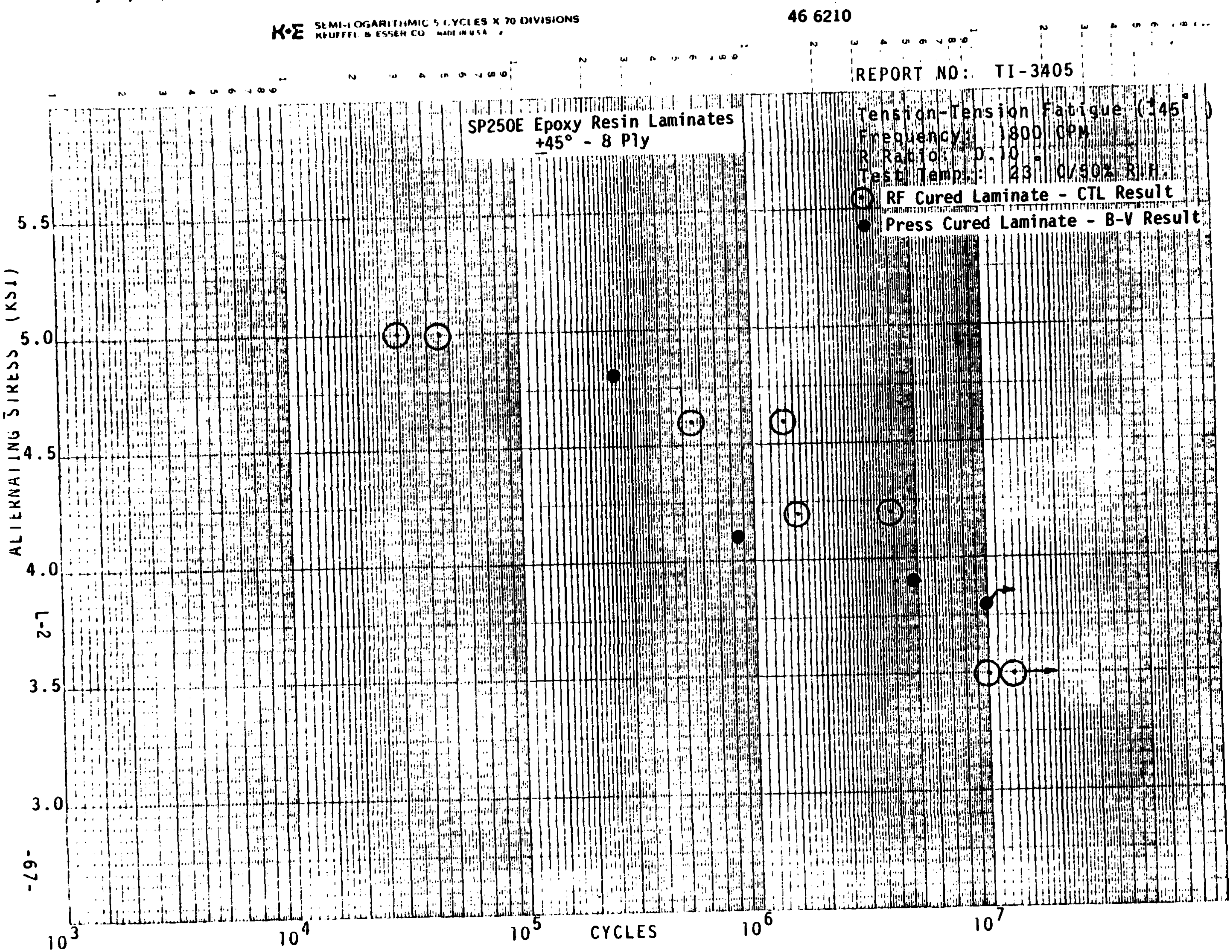
Test Equipment: Satec SF-1U S/N 1131

Specification: BMS 8-196A

Spec. (No.)	Panel (No.)	Max. Stress (KSI)	Static Stress (KSI)	Dynamic Stress (KSI)	Cycles x 10^3	Width (in.)	Thickness (in.)	Remarks
1-F	2	11.11	6.11	5.00	30	.990	.063	Failure
2-F	2	11.11	6.11	5.00	45	.995	.061	Failure
3-F	4	10.22	5.62	4.60	552	.995	.069	Failure
4-F	4	10.22	5.62	4.60	1,370	.993	.070	Failure
5-F	4A	9.33	5.13	4.20	3,875	.995	.069	Failure
6-F	4A	9.33	5.13	4.20	1,532	.994	.070	Failure
7-F	2A	7.78	4.28	3.50	*12,809	.992	.061	Run-out
8-F	2A	7.78	4.28	3.50	*10,088	.990	.059	Run-out

NOTE: All specimens are from constant thickness section

*No Failure


K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6210
REPORT NO: TI-3405
SP250E Epoxy Resin Laminates
+45° - 8 Ply
Tension-Tension Fatigue (±45°)
Frequency: 1800 CPM
R Ratio: 0.10
Test Temp.: 23° C/50% R.H.
RF Cured Laminate - CTL Result
Press Cured Laminate - B-V Result
ALTERNATING STRESS (KSI)
5.5
5.0
4.5
4.0
3.5
3.0
CYCLES
10^3
10^4
10^5
10^6
10^7

L-2

FATIGUE (0°)

CUSTOMER: Boeing Vertol Company | Date: January 22, 1980

Material: SP250-E-33 W-456, Lot 7, Jumbo 50 | R Ratio: 0.10

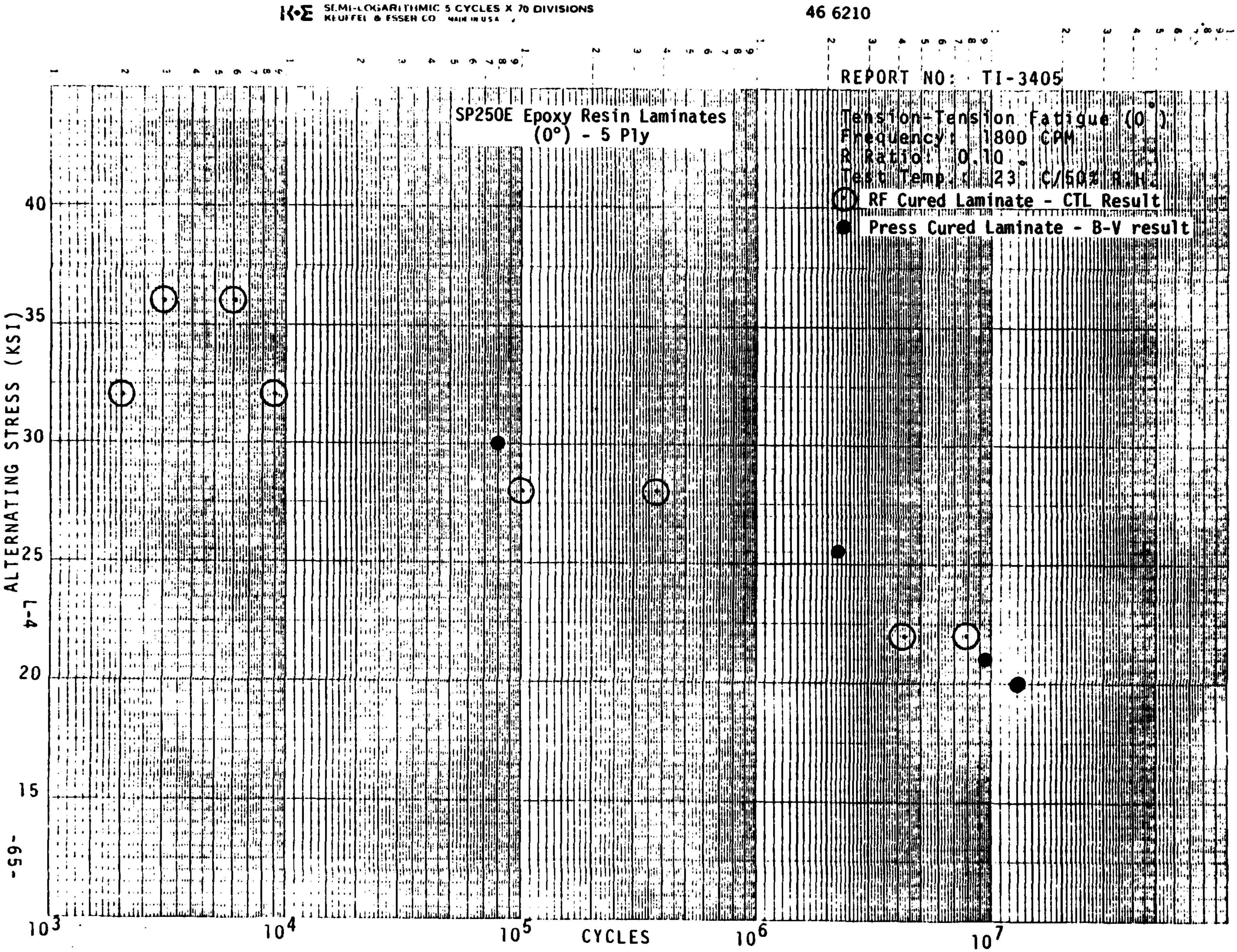
Type Test: Tension-Tension | Pre-Conditioning: 40 hrs/23°C/50% R.H

Frequency: 1800 CPM | Test Condition: 23°C/50% R.H.

Specimen Type: Figure 5 | Test Equipment: Satec SF-1U S/N 1131

Specification: BMS 8-196A

Spec. (No.)	Panel (No.)	Max. Stress (KSI)	Static Stress (KSI)	Dynamic Stress (KSI)	Failure Cycles x 10^3	Width (in.)	Thickness (in.)	Remarks
1-A	2	62.22	34.22	28.00	374	.498	.052	Wedge Section
2-A	4	48.89	26.89	22.00	7,887	.497	.051	Wedge Section
3-A	4	71.11	39.11	32.00	2	.500	.051	Wedge Section
4-A	4-A	62.22	34.22	28.00	103	.497	.051	Wedge Section
5-A	4-A	71.11	39.11	32.00	9	.500	.048	Wedge Section
6-A	2-A	48.89	26.89	22.00	4,251	.500	.050	Wedge Section
7-A	2	80.00	44.00	36.00	6	.500	.045	Constant Thick. Section
8-A	4	80.00	44.00	36.00	3	.502	.043	Constant Thick. Section


K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6210
REPORT NO: TI-3405
SP250E Epoxy Resin Laminates
(0°) - 5 Ply
Tension-Tension Fatigue (0°)
Frequency: 1800 CPM
R Ratio: 0.10
Test Temp.: 23 °C/50% R.H.
RF Cured Laminate - CTL Result
Press Cured Laminate - B-V result
ALTERNATING STRESS (KSI)
40
35
30
25
20
15
CYCLES
10^3
10^4
10^5
10^6
10^7

L-4

APPENDIX M

RF CURED LAMINATE MECHANICAL PROPERTIES

3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR

CONTROL

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A   TEST SPEED: .05 in./Min.

PRE CONDITIONING: 30 Min. @ -65° F   L/D RATIO: 5/1

TEST CONDITION: -65° F   LOAD POINTS RADIUS: Nose 1/8" Supports 1/16

SPECIMEN SIZE: 1/4" x 7/8"

SPAN: .500"

$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lbs.) P	Shear Strength S (PSI)
9 (3W)	.098	.251	400	12,200
20 (3W)	.098	.246	426	13,250
23 (3W)	.102	.251	465	13,620
36 (5W)	.109	.249	369	10,200
49 (5AW)	.104	.252	452	12,930
53 (5AW)	.106	.251	440	12,400
65 (5AW)	.107	.249	392	11,030
92 (3AW)	.097	.248	436	13,590
AVG.	.103			12,400

Test Technician: T. Burns   Approved: D. Browning

T. Burns   D. Browning

3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR

CONTROL

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A TEST SPEED: .05 in./Min.

PRE CONDITIONING: 40 hrs./23° C/50% R.H. L/D RATIO: 5/1

TEST CONDITION: 23° C/50% R.H. LOAD POINTS RADIUS: Nose 1/8" Supports 1/16"

SPECIMEN SIZE: 1/4" x 7/8"

SPAN: .500"

$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lbs.) P	Shear Strength S (PSI)
6 (3W)	.106	.251	360.0	10,150
12 (3W)	.100	.250	298.0	8,940
27 (5W)	.104	.250	343.5	9,910
47 (5W)	.100	.251	314.0	9,380
64 (5AW)	.105	.247	358.0	10,350
71 (5AW)	.108	.250	395.0	10,970
79 (5AW)	.102	.252	357.5	10,430
81 (3AW)	.098	.250	370.0	11,330
AVG.	.103			10,180

Test Technician: R. Bushelman — R. Bushelman Approved: D. Browning — D. Browning

M-5

3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR

CONTROL

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company
MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50
SPECIFICATION: BMS 8-196A TEST SPEED: .05 in./Min.
PRE CONDITIONING: 30 Min. @ 180° F L/D RATIO: 5/1
TEST CONDITION: 180° F LOAD POINTS RADIUS: Nose 1/8" Supports 1/16"
SPECIMEN SIZE: 1/4" x 7/8"
SPAN: .500"

$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lbs.) P	Shear Strength S (PSI)
11 (3W)	.102	.251	205.0	6010
14 (3W)	.096	.251	251.5	7830
17 (3W)	.098	.246	224.5	6980
25 (5W)	.105	.250	277.0	7910
30 (5W)	.106	.252	278.0	7810
40 (5W)	.108	.246	275.5	7780
50 (5AW)	.105	.250	256.0	7310
88 (3 AW)	.098	.249	229.0	7040
AVG.	.102			7330

Test Technician: R. Bushelman Approved: D. Browning

3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR

OIL SOAK*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company
MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50
SPECIFICATION: BMS 8-196A TEST SPEED: .05 in./Min.
PRE CONDITIONING: 30 Min. @ -65°F L/D RATIO: 5/1
TEST CONDITION: -65° F LOAD POINTS RADIUS: Nose 1/8" Supports 1/16'
SPECIMEN SIZE: 1/4" x 7/8"
SPAN: .500"

*Immersed 7 days in Mil-H-83282 hydraulic fluid @ 160° F, removed and MEK wiped.

$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lbs.) P	Shear Strength S (PSI)
15 (3W)	.095	.249	367.0	11,640
22 (3W)	.102	.250	478.0	14,060
38 (5W)	.102	.249	397.0	11,720
55 (5AW)	.107	.251	486.5	13,590
59 (5AW)	.106	.250	370.5	10,490
63 (5AW)	.106	.251	361.0	10,180
72 (5AW)	.111	.248	439.5	11,970
75 (3AW)	.103	.250	396.0	11,530
AVG.	.104			11,900

Test Technician: R. Bushelman R. Bushelman Approved: D. Browning D. Browning
M-9

3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR

OIL SOAK*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company
MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50
SPECIFICATION: BMS 8-196A TEST SPEED: .05 in./Min.
PRE CONDITIONING: 30 Min. @ 23°C/50% R.H. L/D RATIO: 5/1
TEST CONDITION: 23° C/50% R.H. LOAD POINTS RADIUS: Nose 1/8" Supports 1/16"
SPECIMEN SIZE: 1/4" x 7/8"
SPAN: .500"

*Immersed 7 days in Mil-H-83282 hydraulic fluid @ 160° F, removed and MEK wiped.

$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lbs.) P	Shear Strength S (PSI)
3 (3W)	.107	.251	362.0	10,110
19 (3W)	.098	.251	322.5	9,830
24 (3W)	.099	.250	337.5	10,230
32 (5W)	.106	.250	331.0	9,370
35 (5W)	.109	.254	293.5	7,950
57 (5AW)	.108	.251	375.5	10,390
60 (5AW)	.107	.250	310.0	8,690
90 (3AW)	.099	.248	301.5	9,210
AVG.	.104			9,470

Test Technician: R. Bushelman R. Bushelman Approved: D. Browning D. Browning

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR

OIL SOAK*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A TEST SPEED: .05 in./Min.

PRE CONDITIONING: 30 Min.@180° F L/D RATIO: 5/1

TEST CONDITION: 180° F LOAD POINTS RADIUS: Nose 1/8" Supports 1/16"

SPECIMEN SIZE: 1/4" x 7/8"

SPAN: .500"

*Immersed 7 days in Mil-H-83282 hydraulic fluid @ 160° F, removed and MEK wiped.

$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lbs.) P	*Shear Strength* S (PSI)
31 (5W)	.108	.250	283.5	7880
42 (5W)	.107	.253	299.0	8280
51 (5AW)	.105	.251	291.0	8280
58 (5AW)	.104	.251	260.0	7470
61 (5AW)	.107	.253	285.0	7900
67 (5AW)	.099	.248	288.0	8800
74 (3AW)	.105	.252	259.5	7360
91 (3AW)	.099	.254	227.0	6770
AVG.	.104			7840

Test Technician: R. Bushelman R. Bushelman Approved: D. Browning D. Browning

3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR

WATER BOIL*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A TEST SPEED: .05 in./Min.

PRE CONDITIONING: 30 Min. @ -65° F L/D RATIO: 5/1

TEST CONDITION: -65° F LOAD POINTS RADIUS: Nose 1/8" Supports 1/16"

SPECIMEN SIZE: 1/4" x 7/8"

SPAN: .500"

*2 hrs. in boiling distilled water

$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lbs.) P	Shear Strength S (PSI)
1 (3W)	.105	.252	426	12,070
18 (3W)	.098	.249	428	13,150
28 (5W)	.106	.251	500	14,090
29 (5W)	.105	.251	458	13,030
37 (5W)	.104	.249	320	9,270
48 (5W)	.102	.251	410	12,010
52 (5AW)	.105	.252	460	13,040
80 (3AW)	.100	.247	468	14,210
AVG.	.103			12,610

Test Technician: R. Bushelman R. Bushelman

Approved: D. Browning D. Browning

M-15

3W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR

WATER BOIL*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A TEST SPEED: .05 in./Min.

PRE CONDITIONING: 30 Min.@ 23°C/50% R.H. L/D RATIO: 5/1

TEST CONDITION: 23° C/50% R.H. LOAD POINTS RADIUS: Nose 1/8" Supports 1/16"

SPECIMEN SIZE: 1/4" x 7/8"

SPAN: .500"

*2 hrs. in boiling distilled water

$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lbs.) P	Shear Strength S (PSI)
7 (3W)	.103	.252	290.0	8380
8 (3W)	.102	.251	264.0	7730
62 (5AW)	.107	.251	264.5	7390
70 (5AW)	.106	.252	350.0	9830
73 (3AW)	.107	.247	288.5	8190
78 (3AW)	.105	.251	327.5	9320
86 (3AW)	.096	.247	299.0	9460
96 (3AW)	.099	.253	264.5	7920
AVG.	.103			8530

Test Technician: R. Bushelman (R. Bushelman) Approved: D. Browning (D. Browning)

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR

WATER BOIL*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A   TEST SPEED: .05 in./Min.

PRE CONDITIONING: 30 Min. @ 180° F   L/D RATIO: 5/1

TEST CONDITION: 180° F   LOAD POINTS RADIUS: Nose 1/8" Supports 1/16"

SPECIMEN SIZE: 1/4" x 7/8"

SPAN: .500"

*2 hrs. in boiling distilled water

$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lbs.) P	Shear Strength S (PSI)
34 (5W)	.110	.251	171.5	4660
43 (5W)	.095	.251	196.0	6160
46 (5W)	.101	.252	213.5	6290
54 (5AW)	.106	.250	241.5	6830
69 (5AW)	.109	.249	236.0	6520
76 (3AW)	.108	.252	208.0	5730
84 (3AW)	.098	.248	164.5	5030
95 (3AW)	.098	.252	208.5	6330
AVG.	.103			5950

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

M-19

3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR

TEMPERATURE EXPOSURE*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A   TEST SPEED: .05 in./Min.

PRE CONDITIONING: 30 Min. @ -65° F   L/D RATIO: 5/1

TEST CONDITION: -65° F   LOAD POINTS RADIUS: Nose 1/8" Supports 1/16"

SPECIMEN SIZE: 1/4" x 7/8"

SPAN: .500"

*1000 hrs. @ 180° F in a horizontal position

$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lbs.) P	Shear Strength S (PSI)
2 (3W)	.108	.248	438.0	12,260
4 (3W)	.106	.251	498.5	14,050
5 (3W)	.107	.254	447.5	12,350
21 (3W)	.096	.252	412.0	12,770
33 (5W)	.107	.251	416.0	11,620
89 (3AW)	.099	.249	429.5	13,070
93 (3AW)	.099	.251	333.0	10,050
94 (3AW)	.099	.248	374.0	11,420
AVG.	.103			12,200

Test Technician: R. Bushelman   Approved: D. Browning

R. Bushelman   D. Browning

3W = No. 3 Section of Wedqe Panel

5W = No. 5 Section of Wedqe Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR

TEMPERATURE EXPOSURE*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A TEST SPEED: .05 in./Min.

PRE CONDITIONING: 30 Min. @ 23°C/50% R.H. L/D RATIO: 5/1

TEST CONDITION: 23° C/50% R.H. LOAD POINTS RADIUS: Nose 1/8" Supports 1/16"

SPECIMEN SIZE: 1/4" x 7/8"

SPAN: .500"

*1000 hrs. @ 180° F in a horizontal position

$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lbs.) P	Shear Strength S (PSI)
10 (3W)	.103	.252	318.0	9,190
13 (3W)	.096	.249	323.0	10,130
26 (5W)	.103	.247	375.5	11,070
44 (5W)	.094	.251	365.5	11,620
45 (5W)	.095	.253	336.0	10,480
68 (5AW)	.105	.250	342.0	9,770
83 (3AW)	.100	.249	328.5	9,890
85 (3AW)	.095	.251	319.5	10,050
AVG.	.099			10,280

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

SHORT BEAM SHEAR

TEMPERATURE EXPOSURE*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A TEST SPEED: .05 in./Min.

PRE CONDITIONING: 30 Min. @ 180° F L/D RATIO: 5/1

TEST CONDITION: 180° F LOAD POINTS RADIUS: Nose 1/8" Supports 1/16'

SPECIMEN SIZE: 1/4" x 7/8"

SPAN: .500"

*1000 hrs. @ 180° F in a horizontal position

$$S = \frac{3P}{4bd} \text{ PSI}$$

Specimen (No.)	Thickness-d (In.)	Width-b (In.)	Break Load (Lbs.) P	Shear Strength S (PSI)
16 (3W)	.099	.251	244.0	7360
39 (5W)	.101	.250	275.5	8180
41 (5W)	.107	.249	302.0	8500
56 (5AW)	.107	.247	302.5	8580
66 (5AW)	.105	.250	285.0	8140
77 (3AW)	.106	.251	294.5	8300
82 (3AW)	.100	.248	279.5	8450
87 (3AW)	.096	.250	253.0	7910
AVG.	.103			8180

Test Technician: R. Bushelman Approved: D. Browning
R. Bushelman M-25 D. Browning

3AW = No. 3A Section of Wedge Panel

1CT = No. 1 Section of Constant Thickness Panel

3CT = No. 3 Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH

CONTROL

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A SUPPORT RADIUS: 1/8"

PRE CONDITIONING: 30 Min. @ -65° F NOSE RADIUS: 1/8"

TEST CONDITION: -65° F TEST SPEED: .04 in/min

SPAN (L) 1.5 L/d RATIO: 17/1 SPECIMEN LENGTH: 4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3m}{4bd^3}$

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lbs.

b = Specimen width in inches

d = Depth of beam in inches

L = Span in inches

m = Initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lbs.)	m (Lbs./In.)	E_B (PSI x 10^6)
41 (3AW)	269,740	.097	1.000	1128	5581	5.16
53 (1CT)	259,520	.090	1.004	938	4503	5.19
59 (1CT)	235,270	.086	1.006	778	3928	5.18
69 (1CT)	240,010	.091	1.003	886	4332	4.84
72 (3CT)	264,180	.090	1.001	952	4453	5.15
80 (3CT)	263,340	.089	1.001	928	4388	5.25
82 (3CT)	303,530	.083	1.005	934	5031	7.39
94 (3CT)	272,840	.085	0.993	870	4131	5.72
AVG.	263,550	.089				5.49

Test Technician: R. Bushelman R. Bushelman

Approved: D. Browning D. Browning

M-27

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH

CONTROL

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A — SUPPORT RADIUS: 1/8"

PRE CONDITIONING: 40 hrs./23°C/50% R.H. — NOSE RADIUS: 1/8"

TEST CONDITION: 23° C/50% R.H. — TEST SPEED: .04 in/min

SPAN (L) 1.6 — L/d RATIO: 15/1 — SPECIMEN LENGTH: 4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3m}{4bd^3}$

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lbs.

b = Specimen width in inches

d = Depth of beam in inches

L = Span in inches

m = Initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lbs.)	m (Lbs./In.)	E_B (PSI x 10^6)
10 (5W)	205,640	.107	.999	980	6316	5.28
13 (5W)	186,300	.108	.994	900	6316	5.17
20 (5W)	191,580	.103	.999	846	5825	5.46
23 (5AW)	193,270	.108	.988	928	6630	5.45
24 (5AW)	187,430	.109	.998	926	6780	5.37
25 (5AW)	183,820	.107	.983	862	6383	5.43
29 (5AW)	196,550	.107	.994	932	6366	5.35
30 (5AW)	180,460	.107	.999	860	6434	5.38
AVG.	190,630	.107				5.36

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
M-29 D. Browning

1CT = No. 1 Section of Constant Thickness Panel

3CT = No. 3 Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH

CONTROL

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A SUPPORT RADIUS: 1/8"

PRE CONDITIONING: 30 Min. @ 180° F NOSE RADIUS: 1/8"

TEST CONDITION: 180° F TEST SPEED: .04 in/min

SPAN (L) 1.5 L/d RATIO: 17/1 SPECIMEN LENGTH: 4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3m}{4bd^3}$

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lbs.

b = Specimen width in inches

d = Depth of beam in inches

L = Span in inches

m = Initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lbs.)	m (Lbs./In.)	E_B (PSI x 10^6)
45 (1CT)	153,700	.085	1.005	496	4110	5.62
46 (1CT)	164,620	.087	1.004	556	4762	6.08
63 (1CT)	157,110	.089	0.998	552	4688	5.62
65 (1CT)	154,380	.088	1.005	534	4528	5.58
76 (3CT)	160,030	.088	1.004	553	4563	5.63
88 (3CT)	158,430	.080	1.003	452	3448	5.67
90 (3CT)	140,480	.086	0.994	459	3960	5.29
92 (3CT)	157,060	.084	1.007	496	4054	5.73
AVG.	155,730	.086				5.65

Test Technician: R. Bushelman (signature) R. Bushelman

Approved: D. Browning (signature) D. Browning

M-31

3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

1CT = No. 1 Section of Constant Thickness Panel

3CT = No. 3 Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH

OIL SOAK*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A

SUPPORT RADIUS: 1/8"

PRE CONDITIONING: 30 Min. @ -65° F

NOSE RADIUS: 1/8"

TEST CONDITION: -65° F

TEST SPEED: .04 in/min

SPAN (L) 1.5

L/d RATIO: 16/1

SPECIMEN LENGTH: 4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3m}{4bd^3}$

*Immersed 7 days in Mil-H-83282 hydraulic fluid @ 160° F, removed and MEK wiped.

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lbs.

b = Specimen width in inches

d = Depth of beam in inches

L = Span in inches

m = Initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lbs.)	m (Lbs./In.)	E_B (PSI x 10^6)
5 (3W)	203,770	.100	0.996	902	5769	4.89
17 (5W)	245,860	.102	1.001	1138	6667	5.30
48 (1CT)	246,610	.089	1.009	876	4651	5.52
67 (1CT)	260,340	.091	1.004	962	4743	5.29
73 (3CT)	268,270	.089	1.008	952	4706	5.59
77 (3CT)	273,410	.084	1.003	860	4196	5.96
81 (3CT)	251,490	.089	1.003	888	4706	5.62
93 (3CT)	253,820	.086	0.990	826	4040	5.41
AVG.	250,450	.091				5.45

Test Technician: R. Bushelman (signature)
R. Bushelman

Approved: D. Browning (signature)
M-33
D. Browning

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

1CT = No. 1 Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH

OIL SOAK*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A

SUPPORT RADIUS: 1/8"

PRE CONDITIONING: 30 Min. @ 23° C/50% R.H.

NOSE RADIUS: 1/8"

TEST CONDITION: 23° C/50% R.H.

TEST SPEED: .04 in/min

SPAN (L) 1.6 L/d RATIO: 16/1

SPECIMEN LENGTH: 4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3m}{4bd^3}$

*Immersed 7 days in Mil-H-83282 hydraulic fluid @ 160° F, removed and MEK wiped.

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lbs.

b = Specimen width in inches

d = Depth of beam in inches

L = Span in inches

m = Initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lbs.)	m (Lbs./In.)	E_B (PSI x 10^6)
14 (5W)	172,090	.108	0.990	828	6557	5.38
22 (5W)	167,370	.115	0.991	914	7500	5.10
33 (5AW)	168,470	.106	0.994	784	6283	5.43
51 (1CT)	211,260	.090	1.007	718	4301	6.00
54 (1CT)	192,770	.090	0.996	648	4068	5.74
55 (1CT)	196,990	.088	0.999	635	3810	5.73
57 (1CT)	209,020	.089	1.006	694	4138	5.97
70 (1CT)	190,730	.092	1.002	674	4563	5.99
AVG.	188,590	.097				5.67

Test Technician: R. Bushelman

R. Bushelman

Approved: D. Browning

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D. Browning

1CT = No. 1 Section of Constant Thickness Panel

3CT = No. 3 Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH

OIL SOAK*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company
MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50
SPECIFICATION: BMS 8-196A — SUPPORT RADIUS: 1/8"
PRE CONDITIONING: 30 Min. @ 180° F — NOSE RADIUS: 1/8"
TEST CONDITION: 180° F — TEST SPEED: .04 in/min
SPAN (L) 1.5 — L/d RATIO: 17/1 — SPECIMEN LENGTH: 4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3 m}{4bd^3}$

*Immersed 7 days in Mil-H-83282 hydraulic fluid @ 160° F, removed and MEK wiped.

S = Flexural Strength in PSI
E_B = Modulus of elasticity in PSI x 10^6
P = Break load in lbs.
b = Specimen width in inches
d = Depth of beam in inches
L = Span in inches
m = Initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lbs.)	m (Lbs./In.)	E_B (PSI x 10^6)
49 (1CT)	175,240	.086	1.006	579.5	4669	6.16
56 (1CT)	181,760	.084	1.007	574.0	4380	6.19
58 (1CT)	154,270	.091	1.003	569.5	4898	5.47
66 (1CT)	156,510	.091	1.006	579.5	5000	5.57
79 (1CT)	156,080	.090	1.002	563.0	5172	5.98
85 (3CT)	164,260	.089	1.003	580.0	5042	6.02
87 (3CT)	147,930	.085	1.001	475.5	4633	6.36
96 (3CT)	123,880	.081	0.998	360.5	3209	5.11
AVG.	157,490	.087				5.86

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
M-37 D. Browning

3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

1CT = No. 1 Section of Constant Thickness Panel

3CT = No. 3 Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH

WATER BOIL*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A — SUPPORT RADIUS: 1/8"

PRE CONDITIONING: 30 Min. @ -65° F — NOSE RADIUS: 1/8"

TEST CONDITION: -65° F. — TEST SPEED: .04 in/min

SPAN (L) 1.5 — L/d RATIO: 15/1 — SPECIMEN LENGTH: 4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3m}{4bd^3}$

*2 hrs. in boiling distilled water.

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lbs.

b = Specimen width in inches

d = Depth of beam in inches

L = Span in inches

m = Initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lbs.)	m (Lbs./In.)	E_B (PSI x 10^6)
2 (3W)	224,330	.101	0.997	1014	5381	4.42
6 (3W)	204,580	.102	1.000	946	5357	4.26
15 (5W)	217,190	.109	1.001	1148	6704	4.36
38 (5AW)	231,400	.108	0.992	1190	6818	4.60
47 (1CT)	259,720	.089	1.004	918	4461	5.32
62 (1CT)	254,440	.091	1.007	943	4669	5.19
64 (1CT)	264,190	.088	1.003	912	4428	5.47
71 (3CT)	244,610	.092	1.002	922	4959	5.36
AVG.	237,560	.098				4.87

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
M-39 D. Browning

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

1CT = No. 1 Section of Constant Thickness Panel

3CT = No. 3 Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH

WATER BOIL*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A — SUPPORT RADIUS: 1/8"

PRE CONDITIONING: 30 Min. @ 23° C/50% R.H. — NOSE RADIUS: 1/8"

TEST CONDITION: 23° C/50% R.H. — TEST SPEED: .05 in/min

SPAN (L) 1.6 — L/d RATIO: 17/1 — SPECIMEN LENGTH: 4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3m}{4bd^3}$

*2 hrs. in boiling distilled water.

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lbs.

b = Specimen width in inches

d = Depth of beam in inches

L = Span in inches

m = Initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lbs.)	m (Lbs./In.)	E_B (PSI x 10^6)
9 (5W)	172,980	.107	0.984	812	6122	5.20
34 (5AW)	173,360	.103	1.010	774	6283	5.83
61 (1CT)	192,760	.089	1.006	640	4027	5.81
68 (1CT)	181,490	.089	1.005	602	3871	5.59
74 (3CT)	186,280	.093	1.004	674	4196	5.32
75 (3CT)	197,270	.087	1.003	624	3738	5.80
78 (3CT)	189,410	.092	1.006	672	4317	5.64
84 (3CT)	191,600	.080	1.006	514	3077	6.12
AVG.	185,640	.093				5.66

Test Technician: R. Bushelman — R. Bushelman

Approved: D. Browning — D. Browning

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1CT = No. 1 Section of Constant Thickness Panel

3CT = No. 3 Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH

WATER BOIL*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A — SUPPORT RADIUS: 1/8"

PRE CONDITIONING: 30 Min. @ 180° F — NOSE RADIUS: 1/8"

TEST CONDITION: 180° F — TEST SPEED: .04 in/min

SPAN (L) 1.5 L/d RATIO: 17/1 — SPECIMEN LENGTH: 4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3m}{4bd^3}$

*2 hrs. in boiling distilled water.

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lbs.

b = Specimen width in inches

d = Depth of beam in inches

L = Span in inches

m = Initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lbs.)	m (Lbs./In.)	E_B (PSI x 10^6)
50 (1CT)	131,200	.087	1.006	444.0	4054	5.17
52 (1CT)	141,510	.084	1.005	446.0	4013	5.69
60 (1CT)	128,130	.090	0.994	458.5	4563	5.31
83 (3CT)	123,140	.088	1.004	425.5	4317	5.33
86 (3CT)	69,390	.087	0.996	232.5	2941	3.78
89 (3CT)	75,060	.086	0.999	246.5	3158	4.19
91 (3CT)	85,080	.086	0.994	278.0	3324	4.44
95 (3CT)	88,910	.085	1.000	285.5	3093	4.25
AVG.	105,300	.087				4.77

Test Technician: R. Bushelman (signature)
R. Bushelman

Approved: D. Browning (signature)
M-43 D. Browning

3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH

TEMPERATURE EXPOSURE*

DATE: January 22, 1980

CUSTOMER:	Boeing Vertol Company		
MATERIAL:	SP250-E-33 W-456, Lot 7, Jumbo 50		
SPECIFICATION:	BMS 8-196A	SUPPORT RADIUS:	1/8"
PRE CONDITIONING:	30 Min. @ -65° F	NOSE RADIUS:	1/8"
TEST CONDITION:	-65° F	TEST SPEED:	.05 in/min
SPAN (L) 1.7	L/d RATIO: 16/1	SPECIMEN LENGTH:	4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3 m}{4bd^3}$

*1000 hrs. @ 180° F in a horizontal position

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lbs.

b = Specimen width in inches

d = Depth of beam in inches

L = Span in inches

m = Initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lbs.)	m (Lbs./In.)	E_B (PSI x 10^6)
4 (3W)	210,650	.098	.997	791	3582	4.69
12 (5W)	230,900	.103	.991	952	4478	5.08
16 (5W)	234,920	.099	.999	902	4096	5.19
21 (5W)	217,750	.113	.996	1086	5455	4.66
26 (5AW)	239,520	.106	.993	1048	5021	5.21
31 (5AW)	213,040	.106	.995	934	4898	5.08
37 (5AW)	230,300	.114	.990	1162	5333	4.46
42 [illegible]	244,220	.094	.995	842	3509	5.21
	227,660	.104				4.95

R. Bushelman

Approved: D. Browning

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3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH

TEMPERATURE EXPOSURE*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A SUPPORT RADIUS: 1/8"

PRE CONDITIONING: 30 Min. @ 23° C/50% R.H. NOSE RADIUS: 1/8"

TEST CONDITION: 23° C/50% R.H. TEST SPEED: .05 in/min

SPAN (L) 1.7 L/d RATIO: 16/1 SPECIMEN LENGTH: 4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3m}{4bd^3}$

*1000 hrs. @ 180° F in a horizontal position

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lbs.

b = Specimen width in inches

d = Depth of beam in inches

L = Span in inches

m = Initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lbs.)	m (Lbs./In.)	E_B (PSI x 10^6)
1 (3W)	173,260	.097	.998	638	3343	4.51
7 (5W)	186,870	.106	.991	816	5455	5.68
11 (5W)	175,700	.106	.992	768	5381	5.59
18 (5W)	183,640	.105	.995	790	5150	5.49
27 (5AW)	177,620	.110	.999	842	5530	5.11
35 (5AW)	182,240	.109	.994	844	5505	5.25
39 (3AW)	190,360	.099	.995	728	4286	5.45
44 (3AW)	193,170	.099	.994	738	4380	5.58
AVG.	182,860	.104				5.33

Test Technician: R Bushelman
R. Bushelman

Approved: D. Browning
M-47 D. Browning

3W = No. 3 Section of Wedge Panel

5W = No. 5 Section of Wedge Panel

5AW = No. 5A Section of Wedge Panel

3AW = No. 3A Section of Wedge Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

FLEXURAL STRENGTH

TEMPERATURE EXPOSURE*

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A

PRE CONDITIONING: 30 Min. @ 180° F

TEST CONDITION: 180° F

SPAN (L) 1.7 L/d RATIO: 16/1

SUPPORT RADIUS: 1/8"

NOSE RADIUS: 1/8"

TEST SPEED: .05 in/min

SPECIMEN LENGTH: 4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3m}{4bd^3}$

*1000 hrs. @ 180° F in a horizontal position

S = Flexural Strength in PSI

E_B = Modulus of elasticity in PSI x 10^6

P = Break load in lbs.

b = Specimen width in inches

d = Depth of beam in inches

L = Span in inches

m = Initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (PSI)	d (In.)	b (In.)	P (Lbs.)	m (Lbs./In.)	E_B (PSI x 10^6)
3 (3W)	151,570	.095	1.002	537.5	4054	5.79
8 (5W)	120,820	.111	0.991	578.5	5687	5.15
19 (5W)	131,970	.106	0.994	578.0	4938	5.12
28 (5AW)	128,450	.107	0.997	575.0	5172	5.20
32 (5AW)	134,300	.105	0.998	579.5	4959	5.27
36 (5AW)	120,300	.111	0.997	579.5	5530	4.98
40 (3AW)	148,260	.100	0.995	578.5	4317	5.33
43 (3AW)	157,050	.097	0.994	576.0	4225	5.72
AVG.	136,590	.104				5.32

Test Technician: R. Bushelman
R.Bushelman

Approved: D. Browning
M-49 D. Browning

2W = No. 2 Section of Wedge Panel

4AW = No. 4A Section of Wedge Panel

2AW = No. 2A Section of Wedge Panel

2CT = No. 2 Section of Constant Thickness Panel

4CT = No. 4 Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

TENSILE STRENGTH (0°)

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company
MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50
SPECIFICATION: BMS 8-196A
PRE CONDITIONING: 30 Min. @ -65° F
TEST CONDITION: -65° F
SPECIMEN TYPE: Figure 5
TESTING SPEED: .05 in./min.

Tensile Strength (S) = $\frac{P}{bd}$

Modulus of Elasticity (Et) = $\frac{P^*}{bdY}$

*Initial Linear Load

S = Ultimate Tensile Strength in PSI
Sy = Yield Strength in PSI
Et = Modulus of elasticity in PSI x 10^6
P = Break Load in lbs.
b = Specimen width in inches
d = Specimen thickness in inches
Y = Strain in in/in

Specimen (No.)	S (PSI)	Sy (PSI)	P (Lbs.)	d (In.)	b (In.)	Et (PSI x 10^6)	Elongation (%)
3 (2W)	187,940		4730	.052	.484	6.16	
6 (2W)	167,450		4110	.052	.472	6.52	
9 (4AW)	175,400		4410	.051	.493	6.38	
12 (2AW)	178,960		4625	.052	.497	6.39	
15 (2AW)	165,290		4080	.051	.484	6.62	
18 (2CT)	186,470		4120	.045	.491	6.87	
21 (4CT)	104,040		2440	.047	.499	7.32	
24 (4CT)	132,880		2935	.044	.502	7.70	
AVG.	162,300					6.75	

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

2W = No. 2 Section of Wedge Panel

4W = No. 4 Section of Wedge Panel

2AW = No. 2A Section of Wedge Panel

4CT = No. 4 Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

TENSILE STRENGTH (0°)

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company
MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50
SPECIFICATION: BMS 8-196A
PRE CONDITIONING: 40 hrs./23° C/50% R.H.
TEST CONDITION: 23° C/50% R.H.
SPECIMEN TYPE: Figure 5
TESTING SPEED: .05 in./min.

Tensile Strength (S) = $\frac{P}{bd}$

Modulus of Elasticity (Et) = $\frac{P^*}{bdY}$

*Initial Linear Load

S = Ultimate Tensile Strength in PSI
Sy = Yield Strength in PSI
Et = Modulus of elasticity in PSI x 10^6
P = Break Load in lbs.
b = Specimen width in inches
d = Specimen thickness in inches
Y = Strain in in/in

Specimen (No.)	S (PSI)	Sy (PSI)	P (Lbs.)	d (In.)	b (In.)	Et (PSI x 10^6)	Elongation (%)
2 (2W)	134,730		3470	.051	.505	6.01	
5 (2W)	134,740		3370	.052	.481	6.23	
7 (4W)	125,380		3260	.052	.500	6.30	
11 (2AW)	139,190		3590	.052	.496	6.04	
14 (2AW)	159,430		3930	.050	.493	6.32	
19 (4CT)	125,900		2890	.046	.499	6.66	
20 (4CT)	132,040		2870	.044	.494	6.79	
22 (4CT)	124,290		2880	.047	.493	6.77	
AVG.	134,460					6.39	

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

2W = No. 2 Section of Wedge Panel

4W = No. 4 Section of Wedge Panel

4AW = No. 4A Section of Wedge Panel

2AW = No. 2A Section of Wedge Panel

2CT = No. 2 Section of Constant Thickness Panel

4CT = No. 4 Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

TENSILE STRENGTH (0°)

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company
MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50
SPECIFICATION: BMS 8-196A
PRE CONDITIONING: 30 Min. @ 180° F
TEST CONDITION: 180° F
SPECIMEN TYPE: Figure 5
TESTING SPEED: .05 in./min.

Tensile Strength (S) = $\frac{P}{bd}$

Modulus of Elasticity (Et) = $\frac{P^*}{bdY}$

*Initial Linear Load

S = Ultimate Tensile Strength in PSI
Sy = Yield Strength in PSI
Et = Modulus of elasticity in PSI x 10^6
P = Break Load in lbs.
b = Specimen width in inches
d = Specimen thickness in inches
Y = Strain in in/in

Specimen (No.)	S (PSI)	Sy (PSI)	P (Lbs.)	d (In.)	b (In.)	Et (PSI x 10^6)	Elongation (%)
1(2W)	114,050		2920	.051	.502	6.23	
4(2W)	115,180		2890	.051	.492	6.10	
8(4W)	107,960		2665	.051	.484	5.87	
10(4AW)	119,100		3140	.052	.507	5.76	
13(2AW)	112,210		2900	.052	.497	5.89	
16(2AW)	102,810		2565	.050	.499	5.34	
17(2CT)	109,310		2430	.045	.494	6.58	
23(4CT)	109,910		2360	.044	.488	6.88	
AVG.	111,320					6.08	

Test Technician: R. Bushelman
R. Bushelman

Approved: D. Browning
D. Browning

2CT = No. 2 Section of Constant Thickness Panel

4CT = No. 4 Section of Constant Thickness Panel

4ACT = No. 4A Section of Constant Thickness Panel

2ACT = No. 2A Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

TENSILE STRENGTH (0°/90°)

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A

PRE CONDITIONING: 30 Min. @ -65° F

TEST CONDITION: -65° F

SPECIMEN TYPE: Figure 5

TESTING SPEED: .05 in./min.

Tensile Strength (S) = $\frac{P}{bd}$

Modulus of Elasticity (Et) = $\frac{P^*}{bdY}$

*Initial Linear Load

S = Ultimate Tensile Strength in PSI
Sy = Yield Strength in PSI
Et = Modulus of elasticity in PSI x 10^6
P = Break Load in lbs.
b = Specimen width in inches
d = Specimen thickness in inches
Y = Strain in in/in

Specimen (No.)	S (PSI)	Sy (PSI)	P (Lbs.)	d (In.)	b (In.)	Et (PSI x 10^6)	Elongation (%)
1 (2CT)	79,220		5080	.064	1.002	4.44	
5 (2CT)	79,710		5140	.065	0.992	4.11	
11 (4CT)	78,520		5010	.064	0.997	3.98	
14 (4ACT)	75,650		4690	.062	1.000	4.32	
16 (4ACT)	70,210		4480	.064	0.997	4.15	
18 (4ACT)	76,280		4820	.063	1.003	4.27	
19 (2ACT)	83,160		5290	.064	0.994	4.32	
22 (2ACT)	64,260		3980	.062	0.999	4.10	
AVG.	75,880					4.21	

Test Technician: J. Myers Myers Approved: D. Browning D. Browning

2CT = No. 2 Section of Constant Thickness Panel

4CT = No. 4 Section of Constant Thickness Panel

4ACT = No. 4A Section of Constant Thickness Panel

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CONVEYORIZED RADIO FREQUENCY CURE OF EPOXY GLASS COMPOSITES.(U)
MAY 80 L C RITTER DAAG46-79-C-0009

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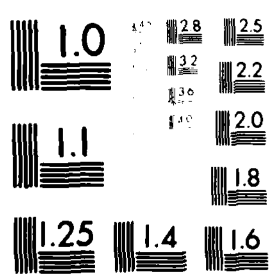

MICROCOPY RESOLUTION TEST CHART

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

TENSILE STRENGTH (0°/90°)

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company
MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50
SPECIFICATION: BMS 8-196A
PRE CONDITIONING: 40 hrs./23° C/50% R.H.
TEST CONDITION: 23° C/50% R.H.
SPECIMEN TYPE: Figure 5
TESTING SPEED: .05 in./min.

Tensile Strength (S) = $\frac{P}{bd}$

Modulus of Elasticity (Et) = $\frac{P*}{bdY}$

*Initial Linear Load

S = Ultimate Tensile Strength in PSI
Sy = Yield Strength in PSI
Et = Modulus of elasticity in PSI x 10^6
P = Break Load in lbs.
b = Specimen width in inches
d = Specimen thickness in inches
Y = Strain in in/in

Specimen (No.)	S (PSI)	Sy (PSI)	P (Lbs.)	d (In.)	b (In.)	Et (PSI x 10^6)	Elongation (%)
3 (2CT)	72,640		4440	.061	1.002	3.83	
6 (2CT)	67,040		4340	.065	0.996	3.66	
8 (4CT)	70,100		4320	.062	0.994	3.96	
9 (4CT)	67,290		4180	.063	0.986	3.63	
12 (4CT)	67,730		4270	.064	0.985	3.44	
15(4ACT)	72,460		4840	.067	0.997	3.69	
20(4ACT)	71,390		4320	.061	0.992	3.76	
23(4ACT)	70,380		4450	.064	0.988	3.72	
AVG.	69,880					3.71	

Test Technician: J. Myers J. Myers Approved: D. Browning D. Browning

2CT = No. 2 Section of Constant Thickness Panel

4CT = No. 4 Section of Constant Thickness Panel

4ACT = No. 4A Section of Constant Thickness Panel

2ACT = No. 2A Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

TENSILE STRENGTH (0°/90°)

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company
MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50
SPECIFICATION: BMS 8-196A
PRE CONDITIONING: 30 Min. @ 180° F
TEST CONDITION: 180° F
SPECIMEN TYPE: Figure 5
TESTING SPEED: .05 in./min.

Tensile Strength (S) = $\frac{P}{bd}$

Modulus of Elasticity (Et) = $\frac{P^*}{bdY}$

*Initial Linear Load

S = Ultimate Tensile Strength in PSI
Sy = Yield Strength in PSI
Et = Modulus of elasticity in PSI x 10^6
P = Break Load in lbs.
b = Specimen width in inches
d = Specimen thickness in inches
Y = Strain in in/in

Specimen (No.)	S (PSI)	Sy (PSI)	P (Lbs.)	d (In.)	b (In.)	Et (PSI x 10^6)	Elongation (%)
2(2CT)	66,520		4170	.063	0.995	3.55	
4(2CT)	61,720		3900	.063	1.003	3.43	
7(4CT)	58,550		3740	.064	0.998	3.52	
10(4CT)	64,490		4090	.064	0.991	3.25	
13(4ACT)	61,560		3790	.062	0.993	3.41	
17(4ACT)	72,300		4590	.064	0.992	3.39	
21(2ACT)	64,410		4170	.065	0.996	3.34	
24(2ACT)	64,070		4000	.063	0.991	3.27	
AVG.	64,200					3.40	

Test Technician: J. Myers J. Myers Approved: D. Browning D. Browning

2CT = No. 2 Section of Constant Thickness Panel

4CT = No. 4 Section of Constant Thickness Panel

4ACT = No. 4A Section of Constant Thickness Panel

2ACT = No. 2A Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

TENSILE STRENGTH (±45°)

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company

MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50

SPECIFICATION: BMS 8-196A

PRE CONDITIONING: 30 Min. @ -65° F

TEST CONDITION: -65° F

SPECIMEN TYPE: Figure 5

TESTING SPEED: .05 in./min.

Tensile Strength (S) = $\frac{P}{bd}$

Modulus of Elasticity (Et) = $\frac{P^*}{bdY}$

*Initial Linear Load

S = Ultimate Tensile Strength in PSI
Sy = Yield Strength in PSI
Et = Modulus of elasticity in PSI x 10^6
P = Break Load in lbs.
b = Specimen width in inches
d = Specimen thickness in inches
Y = Strain in in/in

Specimen (No.)	S (PSI)	Sy (PSI)	P (Lbs.)	d (In.)	b (In.)	Et (PSI x 10^6)	Elongation (%)
1(2CT)	20,170		1272	.063	1.001	2.69	
5(2CT)	20,340		1266	.062	1.004	2.66	
11(4CT)	22,020		1534	.070	0.995	2.69	
14(4ACT)	21,590		1522	.070	1.007	2.67	
16(4ACT)	21,350		1464	.069	0.994	2.82	
18(4ACT)	20,850		1436	.069	0.998	2.88	
19(2ACT)	18,120		1130	.062	1.006	2.65	
22(2ACT)	19,630		1226	.064	0.976	2.58	
AVG.	20,510					2.71	

Test Technician: J. Myers J. Myers

Approved: D. Browning D. Browning

2CT = No. 2 Section of Constant Thickness ?anel

4CT = No. 4 Section of Constant Thickness Panel

4ACT = No. 4A Section of Constant Thickness Panel

2ACT = No. 2A Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

TENSILE STRENGTH ($\pm 45°$)

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company
MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50
SPECIFICATION: BMS 8-196A
PRE CONDITIONING: 40 hrs./23° C/50% R.H.
TEST CONDITION: 23° C/50% R.H.
SPECIMEN TYPE: Figure 5
TESTING SPEED: .05 in./min.

Tensile Strength (S) = $\frac{P}{bd}$

Modulus of Elasticity (Et) = $\frac{P^*}{bdY}$

S = Ultimate Tensile Strength in PSI
Sy = Yield Strength in PSI
Et = Modulus of elasticity in PSI x 10^6
P = Break Load in lbs.
b = Specimen width in inches
d = Specimen thickness in inches
Y = Strain in in/in

*Initial Linear Load

Specimen (No.)	S (PSI)	Sy (PSI)	P (Lbs.)	d (In.)	b (In.)	Et (PSI x 10^6)	Elongation (%)
3(2CT)	18,680		1200	.064	1.004	2.44	
6(2CT)	18,740		1170	.063	0.991	2.21	
8(4CT)	19,060		1450	.077	0.988	1.96	
9(4CT)	20,100		1520	.076	0.995	2.11	
12(4CT)	19,710		1480	.075	1.001	2.01	
15(4ACT)	18,530		1400	.076	0.994	1.97	
20(2ACT)	16,110		1000	.062	1.001	1.92	
23(2ACT)	18,300		1130	.062	0.996	2.14	
AVG.	18,650					2.10	

Test Technician: J. Myers Approved: D. Browning
J. Myers D. Browning

2CT = No. 2 Section of Constant Thickness Panel

4CT = No. 4 Section of Constant Thickness Panel

4ACT = No. 4A Section of Constant Thickness Panel

2ACT = No. 2A Section of Constant Thickness Panel

TEST REPORT

CINCINNATI TESTING LABORATORIES, INC.

REPORT NO. TI-3405

TENSILE STRENGTH (±45°)

DATE: January 22, 1980

CUSTOMER: Boeing Vertol Company
MATERIAL: SP250-E-33 W-456, Lot 7, Jumbo 50
SPECIFICATION: BMS 8-196A
PRE CONDITIONING: 30 Min. @ 180° F
TEST CONDITION: 180° F
SPECIMEN TYPE: Figure 5
TESTING SPEED: .05 in./min.

Tensile Strength (S) = $\frac{P}{bd}$

Modulus of Elasticity (Et) = $\frac{P^*}{bdY}$

*Initial Linear Load

S = Ultimate Tensile Strength in PSI
Sy = Yield Strength in PSI
Et = Modulus of elasticity in PSI x 10^6
P = Break Load in lbs.
b = Specimen width in inches
d = Specimen thickness in inches
Y = Strain in in/in

Specimen (No.)	S (PSI)	Sy (PSI)	P (Lbs.)	d (In.)	b (In.)	Et (PSI x 10^6)	Elongation (%)
2 (2CT)	18,210		1170	.064	1.004	1.47	
4 (2CT)	17,990		1080	.061	0.984	1.59	
7 (4CT)	20,740		1480	.072	0.991	1.62	
10 (4CT)	20,680		1430	.069	1.002	1.77	
13 (4ACT)	19,790		1470	.074	1.004	1.50	
17 (4ACT)	18,920		1350	.071	1.005	1.57	
21 (2ACT)	17,780		1050	.060	0.984	1.76	
24 (2ACT)	17,940		1110	.063	0.982	1.52	
AVG.	19,010					1.60	

Test Technician: J. Myers (signature) J. Myers   Approved: D. Browning (signature) D. Browning

M-67/M-68

APPENDIX N

RESIN GLASS CONTENT AND RETEST DATA

RESIN—GLASS CONTENT

CUSTOMER: Boeing Vertol Company

Material: SP250-E-33 W-456, Lot 7, Jumbo 50, Panel No. 4CTS (0°)

Specification: BMS 8-196A

Pre **Condition:** 16 Hrs. @ 250°F

Burn-off Temp: 1050°F

Specimen Size: 1" x 1"

Specimen No.	1	2	3
Wt. of Crucible & Specimen Before Ignition (gms.)	20.0663	20.5635	19.5728
Wt. of Crucible & Specimen After Ignition (gms.)	19.6824	20.1991	19.2302
Ignition Loss (gms.)	0.3839	0.3644	0.3426
Wt. of Specimen Before Ignition (gms.)	1.8639	1.7355	1.6536
Resin Content (%)	20.6	21.0	20.7
Glass Content (%)	79.4	79.0	79.3

Average Resin Content	20.8	%
Average Glass Content	79.2	%
Average Filler Content		%

RESIN–GLASS CONTENT

CUSTOMER: Boeing Vertol Company

Material: SP250-E-33 W-456, Lot 7, Jumbo 50, Panel No. 4WS (0°)

Specification: BMS 8-196A

Pre Condition: 16 Hrs. @ 250°F

Burn-off Temp: 1050°F

Specimen Size: 1" x 1"

Specimen No.	4	5	6
Wt. of Crucible & Specimen Before Ignition (gms.)	20.1386	20.0883	19.6365
Wt. of Crucible & Specimen After Ignition (gms.)	19.5798	19.6346	19.1299
Ignition Loss (gms.)	0.5588	0.4537	0.5066
Wt. of Specimen Before Ignition (gms.)	1.8821	1.6578	1.8575
Resin Content (%)	29.7	27.4	27.3
Glass Content (%)	70.3	72.6	72.7

Average Resin Content	28.1	%
Average Glass Content	71.9	%
Average Filler Content		%

RESIN—GLASS CONTENT

CUSTOMER: Boeing Vertol Company

Material: SP250-E-33 W-456, Lot 7, Jumbo 50, Panel No. 4AWS (0°)

Specification: BMS 8-196A

Pre Condition: 16 Hrs. @ 250°F

Burn-off Temp: 1050°F

Specimen Size: 1" x 1"

Specimen No.	7	8	9
Wt. of Crucible & Specimen Before Ignition (gms.)	20.4582	19.8761	20.1803
Wt. of Crucible & Specimen After Ignition (gms.)	19.9738	19.4801	19.7888
Ignition Loss (gms.)	0.4844	0.3980	0.3915
Wt. of Specimen Before Ignition (gms.)	1.7068	1.6354	1.6574
Resin Content (%)	28.4	24.2	23.6
Glass Content (%)	71.6	75.8	76.4

Average Resin Content	25.4	%
Average Glass Content	74.6	%
Average Filler Content		%

RESIN—GLASS CONTENT

CUSTOMER: Boeing Vertol Company

Material: SP250-E-33 W-456, Lot 7, Jumbo 50, Panel No. 2CTS (0°)

Specification: BMS 8-196A

Pre Condition: 16 Hrs. @ 250°F

Burn-off Temp: 1050°F

Specimen Size: 1" x 1"

Specimen No.	10	11	12
Wt. of Crucible & Specimen Before Ignition (gms.)	19.5320	20.2985	20.3435
Wt. of Crucible & Specimen After Ignition (gms.)	19.1975	20.0211	20.0131
Ignition Loss (gms.)	0.3345	0.2774	0.3304
Wt. of Specimen Before Ignition (gms.)	1.7331	1.4439	1.5312
Resin Content (%)	19.3	19.2	21.6
Glass Content (%)	80.7	80.8	78.4

Average Resin Content	20.0	%
Average Glass Content	80.0	%
Average Filler Content		%

RESIN—GLASS CONTENT

CUSTOMER: Boeing Vertol Company

Material: SP250-E-33 W-456, Lot 7, Jumbo 50, Panel No. 2AWS (0°)

Specification: BMS 8-196A

Pre Condition: 16 Hrs. @ 250°F

Burn-off Temp: 1050°F

Specimen Size: 1" x 1"

Specimen No.	13	14	15
Wt. of Crucible & Specimen Before Ignition (gms.)	20.0743	20.0721	20.0063
Wt. of Crucible & Specimen After Ignition (gms.)	19.6028	19.7169	19.6693
Ignition Loss (gms.)	0.4715	0.3552	0.3370
Wt. of Specimen Before Ignition (gms.)	2.0975	1.6842	1.5832
Resin Content (%)	22.5	21.1	21.3
Glass Content (%)	77.5	78.9	78.7

Average Resin Content	21.6	%
Average Glass Content	78.4	%
Average Filler Content		%

RESIN—GLASS CONTENT

CUSTOMER: Boeing Vertol Company

Material: SP250-E-33 W-456, Lot 7, Jumbo 50, Panel No. 2WS (0°)

Specification: BMS 8-196A

Pre Condition: 16 Hrs. @ 250°F

Burn-off Temp: 1050°F

Specimen Size: 1" x 1"

Specimen No.	16	17	18
Wt. of Crucible & Specimen Before Ignition (gms.)	19.8984	20.3919	20.2162
Wt. of Crucible & Specimen After Ignition (gms.)	19.4516	19.9202	19.7052
Ignition Loss (gms.)	0.4468	0.4717	0.5110
Wt. of Specimen Before Ignition (gms.)	1.6701	1.6947	1.7789
Resin Content (%)	26.8	27.8	28.7
Glass Content (%)	73.2	72.2	71.3

Average Resin Content	27.8	%
Average Glass Content	72.2	%
Average Filler Content		%

RESIN–GLASS CONTENT

CUSTOMER: Boeing Vertol Company

Material: SP-250-E-33 W-456, Lot 7, Jumbo 50, Panel 2ACTS (0/90°)

Specification: BMS 8-196A

Pre Condition: 16 Hrs. @ 250°F

Burn-off Temp: 1050°F

Specimen Size: 1" x 1"

Specimen No.	28	29	30
Wt. of Crucible & Specimen Before Ignition (gms.)	20.2133	20.6575	21.0743
Wt. of Crucible & Specimen After Ignition (gms.)	19.6115	20.1063	20.5083
Ignition Loss (gms.)	0.6018	0.5512	0.5660
Wt. of Specimen Before Ignition (gms.)	2.2940	2.2273	2.2464
Resin Content (%)	26.2	24.7	25.2
Glass Content (%)	73.8	75.3	74.8

Average Resin Content	25.4	%
Average Glass Content	74.6	%
Average Filler Content		%

RESIN–GLASS CONTENT

CUSTOMER: Boeing Vertol Company

Material: SP-250-E-33 W-456, Lot 7, Jumbo 50, Panel 4ACTS (0/90°)

Specification: BMS 8-196A

Pre Condition: 16 Hrs. @ 250°F

Burn-off Temp: 1050°F

Specimen Size: 1" x 1"

Specimen No.	25	26	27
Wt. of Crucible & Specimen Before Ignition (gms.)	20.9868	21.0973	19.8579
Wt. of Crucible & Specimen After Ignition (gms.)	20.5029	20.4618	19.3532
Ignition Loss (gms.)	0.4839	0.6355	0.5047
Wt. of Specimen Before Ignition (gms.)	2.2352	2.2424	2.0591
Resin Content (%)	21.6	28.3	24.5
Glass Content (%)	78.4	71.7	75.5

Average Resin Content	24.8	%
Average Glass Content	75.2	%
Average Filler Content		%

RESIN–GLASS CONTENT

CUSTOMER: Boeing Vertol Company

Material: SP-250-E-33 W-456, Lot 7, Jumbo 50, Panel 2ACTS (±45°)

Specification: BMS 8-196A

Pre Condition: 16 Hrs. @ 250°F

Burn-off Temp: 1050°F

Specimen Size: 1" x 1"

Specimen No.	19	20	21
Wt. of Crucible & Specimen Before Ignition (gms.)	19.9396	20.5594	20.8888
Wt. of Crucible & Specimen After Ignition (gms.)	19.4829	20.0019	20.4062
Ignition Loss (gms.)	0.4567	0.5575	0.4826
Wt. of Specimen Before Ignition (gms.)	2.1605	2.3032	2.0764
Resin Content (%)	21.1	24.2	23.2
Glass Content (%)	78.9	75.8	76.8

Average Resin Content	22.8	%
Average Glass Content	77.2	%
Average Filler Content		%

RESIN—GLASS CONTENT

CUSTOMER: Boeing Vertol Company

Material: SP-250-E-33 W-456, Lot 7, Jumbo 50, Panel 4ACTS (±45°)

Specification: BMS 8-196A

Pre Condition: 16 Hrs. @ 250°F

Burn-off Temp: 1050°F

Specimen Size: 1" x 1"

Specimen No.	22	23	24
Wt. of Crucible & Specimen Before Ignition (gms.)	20.8087	20.6912	20.6079
Wt. of Crucible & Specimen After Ignition (gms.)	20.2599	20.1024	20.0319
Ignition Loss (gms.)	0.5488	0.5888	0.5760
Wt. of Specimen Before Ignition (gms.)	2.2851	2.4505	2.4058
Resin Content (%)	24.0	24.0	23.9
Glass Content (%)	76.0	76.0	76.1

Average Resin Content	24.0	%
Average Glass Content	76.0	%
Average Filler Content		%

TENSILE STRENGTH (0°)

CUSTOMER: Boeing Vertol Company
Material: SP250-E-33 W-456, Lot 7, Jumbo 50
Specification: BMS 8-196A
Pre Conditioning: 30 Min. @ 180°F
Test Condition: 180°F
Specimen Type: Figure 5

Testing Speed: .05 in./min.

S = Ultimate Tensile Strength in PSI
Sy = yield strength in PSI
Et = modulus of elasticity in PSI x 10^6
P = break load in lbs.
b = specimen width in inches
d = specimen thickness in inches
Y = strain in in./in.

Tensile Strength (S) $= \frac{P}{bd}$

Modulus of Elasticity (Et) $= \frac{P}{bdY}$

PANEL (No.)	Specimen (no.)	S (PSI)	S_y (PSI)	P (lbs.)	d (in.)	b (in.)	Et (psi x 10^6)	Elongation (%)
4CTS	11A	99,950		2330	.047	.496	5.70	
4CTS	12A	110,200		2600	.047	.502	6.18	
4CTS	13A	98,140		2360	.048	.501	6.12	
4WS	14A	127,490		3020	.047	.504	5.74	
4WS	15A	123,500		3050	.049	.504	5.58	
	Avg.	111,860					5.86	

NOTE: Post-cured 16 Hrs. @ 250°F

TENSILE STRENGTH (0°/90°)

CUSTOMER: Boeing Vertol Company
Material: SP250-E-33 W-456, Lot 7, Jumbo 50 (Constant Thick. Section)
Specification: BMS 8-196A
Pre Conditioning: 30 Min. @ -65°F
Testing Speed: .05 in./min.
Test Condition: -65°F
Specimen Type: Figure 5

S = Ultimate Tensile Strength in PSI
Sy = yield strength in PSI
Et = modulus of elasticity in PSI x 10^6
P = break load in lbs.
b = specimen width in inches
d = specimen thickness in inches
Y = strain in in./in.

Tensile Strength (S) = $\frac{P}{bd}$

Modulus of Elasticity (Et) = $\frac{P}{bdY}$

PANEL (NO.)	Specimen (no.)	S (PSI)	S_y (PSI)	P (lbs.)	d (in.)	b (in.)	Et (psi x 10^6)	Elongation (%)
4A	1A	88,200		5850	.066	1.005	4.66	
4A	2A	93,010		6070	.065	1.004	3.89	
2A	3A	91,080		5630	.062	0.997	3.99	
2A	4A	90,050		5460	.061	0.994	4.18	
2A	5A	89,160		5500	.062	0.995	4.50	
	Avg.	90,300					4.24	

NOTE: Post-cured 16 Hrs. @ 250°F

TENSILE STRENGTH (±45°)

CUSTOMER: Boeing Vertol Company
Material: SP250-E-33 W-456, Lot 7, Jumbo 50 (Constant Thick. Section)
Specification: BMS 8-196A
Pre Conditioning: 40 Hrs./23°C/50% R.H.
Testing Speed: .05 in./min.
Test Condition: 23°C/50% R.H.
Specimen Type: Figure 5

S = Ultimate Tensile Strength in PSI
Sy = yield strength in PSI
Et = modulus of elasticity in PSI x 10^6
P = break load in lbs.
b = specimen width in inches
d = specimen thickness in inches
Y = strain in in./in.

Tensile Strength (S) = $\frac{P}{bd}$

Modulus of Elasticity (Et) = $\frac{P}{bdY}$

PANEL (No.)	Specimen (no.)	S (PSI)	S_y (PSI)	P (lbs.)	d (in.)	b (in.)	Et (psi x 10^6)	Elongation (%)
2A	6A	19,050		1205	.063	1.004	1.93	
2A	7A	17,870		1128	.063	1.002	2.09	
2A	8A	19,870		1262	.063	1.008	1.95	
4A	9A	21,640		1512	.070	0.998	2.39	
4A	10A	21,490		1516	.070	1.008	2.60	
	Avg.	19,980					2.19	

NOTE: Post-cured 16 Hrs. @ 250°F

SHORT BEAM SHEAR
CONTROL

CUSTOMER: Boeing Vertol Company

Material: SP250-E-33 W-456, Lot 7, Jumbo 50, Panel No. 5 Wedge Section

Specification: BMS 8-196A

Pre Condition: 30 Min. @ -65°F

Test Speed: .05 in./Min.

L/d ratio: 5/1

Load Points Radius: Nose 1/8" Supports 1/16"

Test Temp: -65°F Rel. Humid. --- % Specimen Size: 1/4" x 7/8"

Shear Strength: $S = \frac{3P}{4bd}$ PSI Span: .500"

Specimen (No.)	Thickness-d (in.)	Width-b (in.)	Break Load (lbs.) - P	Shear Strength
103	.102	.247	385.5	11,480
106	.103	.248	423.5	12,430
109	.107	.248	342.0	9,670
4				
5				

Code:

Avg. S = 11,190 PSI

NOTE: Post-cured 16 Hrs. @ 250°F

Shear Strength: $S = \frac{3P}{4bd}$ PSI Span:

Specimen (No.)	Thickness-d (in.)	Width-b (in.)	Break Load (lbs.) - P	Shear Strength
1				
2				
3				
4				
5				

Code:

Avg. S = PSI

SHORT BEAM SHEAR
OIL SOAK *

CUSTOMER: Boeing Vertol Company

Material: SP250-E-33 W-456, Lot 7, Jumbo 50, Panel No. 5A Wedge Section

Specification: BMS 8-196A

Pre Condition: 30 Min. @ -65°F

Test Speed: .05 in./Min.

L/d ratio: 5/1

Test Temp: -65°F Rel. Humid. --- % Specimen Size: 1/4" x 7/8" Load Points Radius: Nose 1/8" Supports 1/16"

Specimen (No.)	Thickness-d (in.)	Width-b (in.)	Break Load (lbs.) - P	Shear Strength: $S = \frac{3P}{4bd}$ PSI
92	.101	.249	439.5	13,110
98	.102	.249	431.5	12,740
99	.107	.249	489.5	13,780
4				
5				

Span: .500"

* Immersed 7 days in MIL-H-83282 Hydraulic Fluid @ 160°F, Removed and mek wiped.

Code:

Avg. S = 13,210 PSI

NOTE: Post-cured 16 Hrs. @ 250°F

Specimen (No.)	Thickness-d (in.)	Width-b (in.)	Break Load (lbs.) - P	Shear Strength: $S = \frac{3P}{4bd}$ PSI
1				
2				
3				
4				
5				

Span:

Code:

Avg. S = PSI

SHORT BEAM SHEAR

OIL SOAK *

CUSTOMER: Boeing Vertol Company

Material: SP250-E-33 W-456, Lot 7, Jumbo 50, Panel No. 5 Wedge Section

Specification: BMS 8-196A

*. Condition: Immersed 7 days in MiL-H-83282 Hydraulic Fluid @ 160°F, Removed & Mek wiped.

Test Speed: .05 in./Min.

L/d ratio: 5/1

Temp: 23 °C Rel. Humid. 50 % Specimen Size: 1/4" x 7/8"

Load Points Radius: Nose 1/8" Supports 1/16"

Shear Strength: $S = \frac{3P}{4bd}$ PSI Span: .500"

Specimen (No.)	Thickness-d (in.)	Width-b (in.)	Break Load (lbs.) - P	Shear Strength
105	.103	.247	367.0	10,820
108	.102	.249	329.0	9,720
111	.107	.247	314.5	8,920
4				
5				

Code:

Avg. S = 9,820 PSI

NOTE: Post-cured 16 Hrs. @ 250°F

Shear Strength: $S = \frac{3P}{4bd}$ PSI Span:

Specimen (No.)	Thickness-d (in.)	Width-b (in.)	Break Load (lbs.) - P	Shear Strength
1				
2				
3				
4				
5				

Code:

Avg. S = PSI

SHORT BEAM SHEAR

WATER BOIL *

CUSTOMER: Boeing Vertol Company

Material: SP250-E-33 W-456, Lot 7, Jumbo 50, Panel No. 3A Wedge Section

Specification: BMS 8-196A

* Condition: 2 Hrs. in Boiling Distilled Water

Test Speed: .05 in./Min.

L/d ratio: 5/1

Load Points Radius: Nose 1/8" Supports 1/16"

Test Temp: 23 °C Rel. Humid. 50 % Specimen Size: 1/4" x 7/8"

Shear Strength: $S = \frac{3P}{4bd}$ PSI Span: .500"

Specimen (No.)	Thickness-d (in.)	Width-b (in.)	Break Load (lbs.) · P	Shear Strength
100	.098	.249	284.0	8730
101	.098	.249	289.0	8880
102	.098	.248	284.5	8780
4				
5				

Code:

Avg. S = 8800 PSI

NOTE: Post-cured 16 Hrs. @ 250°F

Shear Strength: $S = \frac{3P}{4bd}$ PSI Span:

Specimen (No.)	Thickness-d (in.)	Width-b (in.)	Break Load (lbs.) · P	Shear Strength
1				
2				
3				
4				
5				

Code:

Avg. S = PSI

SHORT BEAM SHEAR

WATER BOIL *

CUSTOMER: Boeing Vertol Company

Material: SP250-E-33 W-456, Lot 7, Jumbo 50, Panel No. 5 Wedge Section

Specification: BMS 8-196A

Pre Condition: 30 Min. @ 180°F

Test Speed: .05 in./Min.

L/d ratio: 5/1

Test Temp: 180°F   Rel. Humid. --- %   Specimen Size: 1/4" x 7/8"   Load Points Radius: Nose 1/8" Supports 1/16"

Shear Strength: $S = \frac{3P}{4bd}$ PSI   Span: .500"

Specimen (No.)	Thickness-d (in.)	Width-b (in.)	Break Load (lbs.) - P	Shear Strength (PSI)
104	.104	.247	205.0	5990
107	.104	.247	207.5	6060
110	.107	.248	179.0	5060
4				
5				

* 2 Hrs. in Boiling Distilled Water

Code:

Avg. S = 5700 PSI

NOTE: Post-cured 16 Hrs. @ 250°F

Shear Strength: $S = \frac{3P}{4bd}$ PSI   Span:

Specimen (No.)	Thickness-d (in.)	Width-b (in.)	Break Load (lbs.) - P	Shear Strength (PSI)
1				
2				
3				
4				
5				

Code:

Avg. S = PSI

FLEXURAL STRENGTH

WATER BOIL *

CUSTOMER: Boeing Vertol Company

Material: SP250-E-33 W-456, Lot 7, Jumbo 50, Panel No.3CTS

Specification: BMS 8-196A

* Pre Conditioning: 2 Hrs. in Boiling Distilled Water

Test Condition: 30 Min. @ 180°F, tested @ 180°F

Span (L) 1.5 L/d Ratio: 17/1

Support radius: 1/8"

Nose radius: 1/8"

Test Speed: .04 in./min.

Specimen length: 4"

Flexural Strength (S) = $\frac{3PL}{2bd^2}$

Modulus of Elasticity (E_B) = $\frac{L^3m}{4bd^3}$

S = flexural strength in psi

E_B = Modulus of elasticity in psi x 10^6

P = Break load in lbs.

b = specimen width in inches

d = depth of beam in inches

L = span in inches

m = initial slope of load-deflection curve in lbs./in.

Specimen (No.)	S (psi)	d (in.)	b (in.)	P (lbs.)	m (lbs./in.)	E_B (psi x 10^6)
97	132,650	.092	1.011	504.5	4348	4.66
98	134,290	.089	1.009	477.0	4152	4.93
99	116,800	.086	1.008	387.0	3738	4.92
~~4~~						
~~5~~						
Avg.	127,910	.089				4.84

NOTE: Post-Cured 16 Hrs. @ 250°F

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CONVEYORIZED RADIO FREQUENCY
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Lawrence C. Ritter

Technical Report AVRADCOM TR 80-F-16, May 1980,
276 pp – illus-table, D/A Project 1767042,
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Key Words

Radio Frequency Cure
Fiberglass Epoxy
Laminates
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Prepreg
Time-Temperature Cure

The purpose of this work is to develop a dielectric heating capability for curing fiber reinforced composite structure. The specific objectives were to develop optimum radio frequency (rf) cure cycles for resin/fiber composites, establish process parameters relative to feed rate, rf power levels, electrode spacing, and material thickness variations.

Present manufacturing technology for curing epoxy/fiber composite structure involves the use of large energy consuming facilities (ovens, autoclaves, resistant or radiant heaters, etc.) which entail costly flow times. The use of direct dielectric heating can provide, in some instances, a cost effective alternate curing method. It has been shown that a cost savings of 75 percent can be realized by the use of radio frequency curing over conventional curing by conduction heating.

In the basic principles applied to cure by dielectric heating, an alternating electric field causes oscillatory displacements in the charged components of the dielectric, the energy for motion being absorbed from the electric field. The energy absorbed by the molecules is translated into rotational kinetic energy of the entire molecule, resulting in a temperature increase.

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